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 – 18A
(Syllabi for Mechatronics Engineering 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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Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MHE401T	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	21MHE404T
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 the fundamental concepts and terminologies used in industrial robots
CLR-2:	provide the concepts of spatial transformations associated with rigid bodies and their application in robotics
CLR-3:	gain knowledge on how to derive the forward kinematic model of a serial manipulator
CLR-4:	introduce the various sensors and actuators used in the manipulator
CLR-5:	introduce the concept of trajectory planning and industrial work cell

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 fundamental components and basic terminologies used in robotics	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	apply vector transformations and coordinate transformations in robotics	-	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	compute the forward kinematics for various robot configurations	-	3	2	-	-	-	-	-	-	-	-	-	-	2	
CO-4:	gain knowledge on different sensors, actuators and vision systems used in robots	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	understand various work cell configurations and trajectory planning techniques	3	2	-	-	-	-	-	-	-	-	-	-	-	-	2

Unit-1 - Introduction to Robotics — **9 Hour**

Definition and Evolution of Robots , Laws of Robotics , Basic terminologies in robotics, Robot Anatomy – Types of Joints & Links, Degrees of Freedom , Joint space and Cartesian Space, Classification of robot based on application and work volume, End-effector- types, Types of gripper, Choice of gripper, Industrial Manipulator datasheet interpretation and key specifications , Industrial Controller and Programming

Unit-2 - Transformations — **9 Hour**

Review of vectors and linear algebra, Description of point and objects in Space, Rotation of Vectors, Translation of Vectors, Homogeneous transformation- Combined rotation and translation of vectors, Operators and mapping concept, Composite transformation and its application, Representing Rotations of bodies - Fixed angle, Euler angle, Equivalent axis representation, Simulation exercise (Transformations)

Unit-3 - Manipulator Kinematics — **9 Hour**

Introduction to Manipulator Kinematics, DH formulation (standard method), Forward kinematics of RR planar manipulator-geometric approach and using DH method, Forward kinematics of 3R spatial articulated arm- using DH method, Forward kinematics of RPY wrist- using DH method, Forward kinematics of 4 DoF SCARA robot- using DH method, Computing DH parameters for 6 DoF industrial manipulator, Inverse kinematics-concept and basics, Issues in inverse kinematics, Inverse kinematics of RR planar manipulator-geometric approach, Simulation exercise (Forward Kinematics)

Unit-4 - Sensors and Actuators in Robotics — **9 Hour**

Sensors in Robots, Proprioceptive Sensors and Exteroceptive Sensors-Absolute and Incremental Encoder, Force sensors, tactile sensors, slip sensors, Camera, Depth sensors and their uses, Sensor calibration and interfacing concepts , Actuators-Electrical (DC Motors, Stepper motors, Induction motors), pneumatic and hydraulic, Concept of Actuator drives, Harmonic drives.

Unit-5 - Trajectory Planning and Robot Work Cell — **9 Hour**

Introduction to trajectory planning, Joint space trajectory planning - Cubic polynomial, Via points; Cartesian space planning, Point to point, continuous path planning, Robot work cell layout, work cell control, safety monitoring.

Learning Resources	1. *Kevin M. Lynch and Frank C. Park, "Modern Robotics: Mechanics, Planning and Control", 1st edition, Cambridge University Press,2017.* 2. *Bruno Siciliano and Oussama Khatib, "Handbook of Robotics",Springer-Verlag, 2016.* 3. *Harry H. Poole, "Fundamentals of Robotics Engineering", Springer,2012.* 4. *Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, Wiley Publishers, 2010.*	5. *John J.Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Pearson Education, 2009.* 6. *Mittal R.K. and Nagrath I.J., "Robotics and Control", 1st edition, TataMcGraw 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*	*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. Mohammed Sagheer, ZF commercial vehicle control systems Pvt.Ltd*	1. *Dr. G Nagamanikandan, IIIT Hyderabad*	1. *Dr. Ranjith Pillai R, SRMIST*
2. *Mr. Ganesh Ram, Tunga Systems*	2. *Dr. R Thiyagarajan, IIT Tirpuati*	2. *Dr. S Anitha Kumari, SRMIST*

Course Code	21MHE402L	Course Name	VISUAL COMPUTING LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*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:	*develop python programs for data visualization using object-oriented programming constructs*
CLR-2:	*explore various digital image processing algorithms*
CLR-3:	*impart knowledge of different algorithms used in computer vision and video processing*
CLR-4:	*incorporate computer graphics in computer vision applications*
CLR-5:	*construct the requirements for developing a VR/AR interface*

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:	*develop computer programs for data visualization in python*	-	*1*	*3*	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply various spatial and frequency domain algorithms for digital image processing*	-	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*analyze different algorithms to extract features from digital image and video data*	-	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*define the operations and algorithms used in generating computer graphics*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*develop VR/AR interface for an application*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Review of Python and Data Visualization	***15 Hour***
Review of data types, operators, and data containers - Conditional statements - Iterative loops - Functions and scope of variables - Modules - File I/O - Error handling – Classes and objects - Object-oriented programming concepts - Plots for presenting comparison - Plots for presenting relationship - Plots for presenting distribution - Plots for presenting composition - 2D animated plots for visualization - 3D animated plots for visualization	
Unit-2 - Digital Image Processing	***15 Hour***
Understanding sampling and quantization in digital images, types of digital images - Point operations - 2D convolution - Spatial smoothing of images using convolution - Image differentiation and edge detection - Order statistical filtering of images - Morphological operations - Color image processing - Texture analysis - Image acquisition from cameras, multi-camera image acquisition- Working with specifications of a camera - LIDAR data processing - Fusing LIDAR data with RGB images - Introduction to frequency domain image processing - Frequency domain smoothing and sharpening	
Unit-3 - Computer Vision and Video Processing	***15 Hour***
Camera modeling - Camera calibration - Geometry of multiple images – Homographies - Key point descriptors - Key point matching - Region-based dense matching - Computational stereo vision for scene reconstruction - Optical flow - LK method for optical flow estimation and visualization - Farneback method for optical flow estimation and visualization - Visual tracking - Visual odometry	
Unit-4 - Computer Graphics	***15 Hour***
2D & 3D Scaling - Translation and rotation - Composite transformation - Window to viewpoint transformations - Orthographic and perspective projections - Algorithms for drawing primitive shapes - Working with meshes - Shearing and reflection - Filling algorithms – Clipping - Basic rendering - Camera Movement - Optimization in Drawing - 3D Objects -Animations	
Unit-5 - Virtual and Augmented Reality	***15 Hour***
Understanding scene graphs and 3D models - Working with parent-child relationships - Working with windows, viewpoints, color texture, visibility - Avatars and actions -Texture, lighting, and Shaders - Graphical user interface - Animation paths and proximity sensing - Physics in VR - Tools and hardware connection - Linking, grabbing and merge linking - Flow control and tasks - 2D data code detection - Marker-based augmented reality - Marker free augmented reality - Spatial mapping and pose tracking – Simple mixed reality applications.	

Learning Resources	1. *Rafael C. Gonzales, Richard. E. Woods, "Digital Image Processing,4th Edition, Pearson Education", 2018.* 2. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques for 3D Computer Vision", 1st Edition, Prentice Hall, 1998.* 3. *Alexander Hornberg, "Handbook of Machine Vision", 2ndEdition, Wiley, 2006.*	4. *Wiley Forsyth and Ponce, "Computer Vision: A Modern Approach", 2ndEdition, Pearson, 2015.* 5. *https://www.udemy.com/course/learn-opengl-with-python-for-graphics- and-games.* 6. *WorldViz Vizard VR Software Documentation*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Shankar Bharathi, L&T Technology Services,*	1. *Dr. G. Nagamanikandan, IIIT Hyderabad*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Mohammed Sagheer, WABCO Technology Center,India*	2. *Dr. R. Thiyagarajan, IIT Tirupati*	2. *Mrs. G. Madhumitha, SRMIST*

Course Code	21MHE403T	Course Name	INDUSTRIAL ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MHC201T*	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 different Regulators and utilize them in different Regulated Power supply circuits*
CLR-2:	*recognizes the concept of heating and welding*
CLR-3:	*identify the industrial applications of power semiconductor devices*
CLR-4:	*apply Power semiconductor switching devices concept in industrial applications*
CLR-5:	*acquire knowledge on Wireless Power Transfer 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 various regulators used in Power supplies*	*3*	*1*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*interpret the working principle of heating and welding in order to apply the advanced controls*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*analyze the functions of several industrial motor controls*	*3*	*1*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*operate various industrial appliances using Power semiconductor switching devices and servo system using Choppers*	*3*	*1*	*1*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*design Wireless power transfer circuits for various applications*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Regulators and Power Supplies ***9 Hour***

Regulated power supply: Concept of regulation, line and load regulation, output ripple and transients. Series regulators with protection. Concepts of fold back limiting, short circuit and overload protection. Three terminal voltage regulator ICs: Positive, negative and variable applications. Switched Mode Power Supply: Basic working principles and applications. Concept of floating and grounded power supplies: interconnections to obtain multiple output supplies. Analysis of Switch Mode Power Supply: Fly back converter, forward/buck converter, Boost converter and buck-boost converter

Unit-2 - Heating and Welding Control ***9 Hour***

Electronic control of heating: Introduction, types. Induction heating - principle of operation. Effects of supply frequency and source voltage, choice of frequency. Types and operation of High frequency induction heating, operation of electronic heaters employed in induction heating. Thyristorised supplies used in induction furnaces. Dielectric heating: Working principle and applications. Simple problems related to dielectric heating. Electronic control of welding, electric welding - types. Classification of resistance welding. Operation of control circuit for resistance welding, AC resistance heating

Unit-3 - Industrial Application of Power Switching Devices ***9 Hour***

PLL control of a dc motor control, Operation of different methods of Speed control of single phase induction motor, TRIAC as a starter for single phase induction motor, operation of universal series motor -Principle of operation of automatic battery charger using SCR, trickle charging. Principle of operation of emergency light using SCR, time delay relay circuit. Principle of operation of battery operated inverter circuit using power transistor. Principle of operation of Illumination control using SCR, using DIAC, TRIAC. Principle of operation of automatic temperature control circuit. Different methods of control circuit, electronic timers – types. Industrial applications - Industrial timers – Classification, Types, Electronic timers – Classification, RC and digital timers, Time base generators.

Unit-4 - AC Power Conditioner	**9 Hour**
Power supply noise - different forms of noise. Servo system - fundamentals and working principle. Principle of buck - boost control of a servo controlled voltage stabilizer. Ferro resonant AC regulator - Synchro, Constructional features and working principle. UPS - Principle of operation of online and offline UPS. Comparison of the types of UPS. Zero voltage switching circuit and working principle, have Synchronous tap changer circuit, and AC power controlled of a lamp dimmer circuit- working principle. Applications of AC line voltage controller's circuit.	
Unit-5 - Wireless Power Transfer and its Applications	**9 Hour**
Wireless Power Transfer: Introduction. Methods of Wireless power transfer. Inductive WPT system applications. Resonant Inductive WPT System Design - System Components,Operating Field Region, Efficiency Equations. WPT Systems with Multiple Coils - Single Transmitter and Receiver with Multiple Coils in between, Multiple Transmitters and Single Receiver, Single Transmitter and Multiple Receivers. WPT Power Source Converter - Class-D Inverter, Class-E Inverter. Efficient Magnetic Link Design. Energy harvesting methods.	

Learning Resources	1. *S. Bhattacharya, S. Chatterjee, "Industrial Electronics and Control", Tata McGrawHill, 2006.* 2. *Dubey, G.K., Doradia, S.R., Joshi, A. and Singh, R.M., "Thyristorised PowerControllers", Wiley Eastern Limited, 2nd Edition, 2010.* 3. *Biswanath Paul, "Industrial Electronics and Control", Prentice Hall India Publisher,3rd Edition, 2014.* 4. *Chitode .J.S, "Industrial Electronics", Technical Publications, 2009.* 5. *G.K. Mithal and Maneesha Gupta, "Industrial and Power Electronics", KhannaPublishers, 19th Ed., 2003.*	6. *M. H. Rashid, "Power Electronics Circuits, Devices and Application", Prentice Hall of India, 3rd edition, 2004.* 7. *Terry Baltelt, "Industrial electronics, devices, systems and applications", Delmar publishers, 2006.* 8. *Stephan L.Herman, Walter N.Alerich, "Industrial Motor Control", 4th edition, Delmar publishers, 2010.* 9. *Mohammad .H.Rashid," Power Electronics Hand book", Butterworth-Heinemann 2017, 4th Edition, 2018.*

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. *J.Aran Glenn, Senior Engineer, EV Product Design*	1. *Dr.Sreejith.S, National Institute of Technology, Silchar*	1. *Dr. V. Krithika, SRMIST*
2. *Dr. K. Sridharan, Quest Engineering Services , Bangalore,*	2. *Dr.T.Sasilatha, AMET,Chennai*	2. *Dr. M. Belsam Jeba Ananth, SRMIST*

Course Code	21MHE404T	Course Name	ROBOT KINEMATICS AND DYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the concept of inverse kinematics and its computation method for various configurations of Robot*
CLR-2:	*familiarize the concepts of differential kinematics of serial manipulator and their application*
CLR-3:	*gain knowledge in the formulation of the dynamic model of serial robots*
CLR-4:	*gain knowledge in the design and architecture of popular position and force control schemes used in industrial robots*
CLR-5:	*understand the concept of parallel configuration of robots and its kinematics computation method*

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 concept of inverse kinematics and its computation method*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*derive the Jacobian matrix for the serial manipulators and compute the singularity condition*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*derive the dynamic model of a planar arm manipulator*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*understand the design and implementation of popular position and force control schemes used in industrial manipulators*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*understand the concept of parallel manipulator and its kinematic computation*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Forward and Inverse Kinematics — ***9 Hour***

Forward kinematics of 6 DoF manipulators (examples of PUMA and Stanford arm), Concept of inverse kinematics, Solution methods – geometric, iterative and analytical, Workspace of the manipulator, Issues in the solvability of inverse kinematics, Inverse kinematics of 2R planar arm using the geometric approach, Inverse kinematics computation using the analytical approach for 3R spatial arm, RPY wrist, RPPR arm.

Unit-2 - Differential Kinematics and Singularity — ***9 Hour***

Description/Notation for time-varying position and orientation of rigid bodies, Study of Linear and angular velocity of rigid bodies, Velocity propagation along links, Concept of manipulator Jacobian and its uses, Jacobian computation method, Jacobian computation (Linear and Angular velocity Jacobian) for RR, RPY and spatial 3R serial manipulators, Concept of singularity in manipulator and its consequences, Singularity computation in serial manipulators, Concept of manipulability and dexterity in serial manipulators.

Unit-3 - Dynamics of Manipulators — ***9 Hour***

Introduction to Dynamics and its importance, General dynamic description, and terms like- Inertia, centrifugal, and Coriolis forces. Dynamic model computation method: Lagarangian Euler and Newton Euler formulation (with an example of mass spring damper system). Dynamic model derivation for: 1 DoF rotary joint, planar 2R manipulator, planar RP manipulator. Dynamic model of the pendulum over a cart and its simulation. Introduction to statics, Jacobian in statics, Computation of static forces for manipulators (with numerical examples).

Unit-4 - Position and Force Control — ***9 Hour***

Introduction to control of serial manipulators, joint space and cartesian space control, Partition control scheme – Partition PD control applied to 1 DoF rotary joint,PID control scheme for 1 DoF rotary joint, Computed torque control method for manipulators, Force control in manipulators, Description of force tasks natural and artificial constraints (with example of peg in hole assembly), Hybrid force/position control architecture.

Unit-5 - Parallel Manipulator — ***9 Hour***

Introduction to parallel manipulators, Comparison of serial and parallel manipulators, various configurations of parallel manipulators and their degree of freedom computation, Inverse kinematics computation approach: using vector loop equation, Inverse kinematics of 3 DoF spatial parallel manipulator and 3 DoF planar parallel manipulator, Concept of Jacobian and singularities in parallel manipulator.

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2ndedition, Wiley India, 2008.* 3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.* 4. *Saeed B.Niku, "Introduction to Robotics Analysis, Systems andApplications", 2nd edition, Prentice Hall of India, 2009.*	5. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition,Prentice Hall of India Learning, 2009.* 6. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGrawHill, 2007.* 7. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition McGraw Hill, 2008.* 8. *Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition,MIT Press, 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*	*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.Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd*	1. *Dr.G Nagamanikandan, IIIT Hyderabad*	1. *Dr.Ranjith Pillai R, SRMIST*
2. *Mr.Ganesh Ram, Tunga Systems*	2. *Dr.R Thiyagarajan, IIT Tirpuati*	2. *Dr.A Vimala Starbino , SRMIST*

Course Code	21MHE405L	Course Name	NEURAL NETWORKS AND DEEP LEARNING LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	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 awareness about the capabilities of machine learning*
CLR-2:	*set up a machine learning problem with a neural network mindset*
CLR-3:	*build neural network model for classification and regression*
CLR-4:	*implement on various aspects of hardware software speedup for machine learning*
CLR-5:	*develop and train deep neural networks for computer vision task*

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 with the basic concepts on Machine Learning*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*incorporate vectorization to speed up the models*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*implement the concepts of CNN and RNN*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*analyze the capabilities, challenges, and consequences of deep learning*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate the key computations underlying deep learning*	*3*	-	*2*	-	-	-	-	-	*1*	-	-	-	-	-	*2*

Unit-1 - Basics of Machine Learning API ***15 Hour***

Introduction to artificial intelligence – Intelligent agent – categorization of AI – overview of different forms of learning, introduction to machine learning, deep learning, comparison with classical non-machine learning approaches, introduction to data sets - generalization – overfitting and under fitting – regularization techniques – hyper parameters and tuning – classification and regression – performance evaluation metrics for classification and regression algorithms, linear regression.

Unit-2 - Classical Neural Networks ***15 Hour***

Basics of neural network – single neuron learning - Foundation of gradient based optimization - Understanding derivative - Types of gradient descent - Chaining derivatives – Back propagation algorithm - Running one training example from the scratch - Running one training example from the scratch - Multilayer perceptron – Learning Boolean functions - Activation functions - vanishing gradients - over-fitting and under-fitting - Applying trained networks for prediction - Image classification with multi-layer perceptron - Neural network for regression with example

Unit-3 - CNN and RNN ***15 Hour***

Motivation for CNN - 1D, 2D and 3D convolutions - Convolutional neuron - Pooling layers and Initialization - Understanding Softmax Function - LeNet for hand- written digit classifications - Alexnet Implementation for Imagenet Classification - CNN for Regression- Understanding the principle and Motivation for RNNs - Basic RNN for Forecasting application - Advanced usage of RNN - RNN for Image Classification - LSTM Motivation and Principle Understanding - LSTM for sequential learning

Unit-4 - Training Strategies ***15 Hour***

Loss functions - Evaluation metrics for classifications tasks - Evaluation metrics for regression tasks - Batching, Shuffling, Regularization – Dropouts – Optimizers – Momentum, Nestrov, RMS Prop, AdaDelta, ADAM, ADAGRAD - Hyperparameters Tuning - Batch Normalization - Understanding deep learning hardware for training and inference - Measuring deep learning hardware related parameters - Hardware training distribute strategies - Complete training and benchmarking for an image classification task

Unit-5 - Advanced Architectures and Embedded Implementations	***15 Hour***
ResNet/ Inception - Key Aspects - Recent Image Classification Architectures – Key Aspects - Object Detection by RCNN and YOLO - Object Tracking by SORT- Sementic Segmentation using U-Net/Auto encoders, instance segmentation/image panoppic segmentation – video panoptic segmentation – attention network with application	

List of Recommended Practical Exercises	
1. *Getting started with ML training with GUI based exploratory tool Eg. Tensorflow Playground*	9. *Basic RNN for forecasting application*
2. *Classifying images with GUI based ML training tool Eg Teachable Machine*	10. *LSTM for Sequence Learning*
3. *Understanding loss functions and performance metrics*	11. *Implementation of optimizers and comparison of performance*
4. *Linear regression algorithm and computation of its performance metrics*	12. *GPU implementation for training and speed-up strategies for inference*
5. *Implementing Gradient Descent types*	13. *Object Detection Transfer Learning Implementation*
6. *Implementing a multi-layer perceptron from scratch*	14. *Semantic Segmentation implementation from the scratch*
7. *Image classification using multi-layer classical NN*	15. *Visual tracking or Video Panoptic Segmentation using a pre-trained network*
8. *Color image classification using CNN*	

Learning Resources		
	1. *Bharath Ramsundar, Reza Bosagh Zadeh, TensorFlow for Deep Learning, O'Reilly Media, 2018*	3. *Eli Stevens, Luca Antiga, Thomas Viehmann, Deep Learning with PyTorch,Manning, 2020*
	2. *Antonio Gulli, Amita Kapoor, Sujit Pal, Deep Learning with TensorFlow 2 and Keras, Packt Publishing, 2019*	4. *Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press,2016*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (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. Mohammed Sagheer, Wabco Technology Center,*	1. *Dr. Thiyagarajan, Indian Institute of Technology Tirupati.*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Shankar Bharathi, Larsen & Toubro Technology Services, shankarbharathi.s@ltts.com*	2. *Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	2. *Mrs.T.S.Rajalakshmi, SRMIST*

Course Code	21MHE406T	Course Name	VIRTUAL INSTRUMENTATION	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:	*introduce virtual instrumentation and graphical programming*
CLR-2:	*discuss and compare various data acquisition techniques*
CLR-3:	*acquire knowledge of various instrumentation interfaces*
CLR-4:	*realize virtual instruments for signal generation, measurement, and analysis*
CLR-5:	*explore the applications of virtual instrumentation*

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:	*describe the concepts in virtual instrumentation and graphical programming*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*select and configure various data acquisition devices*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*articulate various instrumentation interfaces to connect external hardware to a computer*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*develop virtual instruments for signal generation, measurement, and analysis*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*identify the applications of virtual instrumentation*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Virtual Instrumentation and Graphical Programming	***9 Hour***
Concept and evolution of virtual instrumentation - Block diagram and architecture of virtual instrumentation - Graphical programming vs. conventional programming, pros, and cons - Front panel, block diagram, data-flow, and data types - Loops - Case structure - Sequence - Charts - Graphs - Array - Cluster - Formula nodes - Scope of variables and sub-VIs - Strings and File I/O	
Unit-2 - Data Acquisition Techniques	***9 Hour***
Analog and digital signals representation, sample and hold, quantization and encoding - Introduction to data acquisition systems and PC-based data acquisition - Effect of variation of different parameters on data acquisition - I/O techniques - Selecting and configuring data acquisition devices - Analog data acquisition modules - Digital data acquisition modules - Universal data acquisition modules - Embedded reconfigurable I/O platforms - Timers and Counters	
Unit-3 - Instrumentation Interfaces	***9 Hour***
Introduction to interfaces and their importance - Overview of RS232, RS485, Ethernet, USB, and GPIB - Need, architecture, and features of PCI, PCIE, SCXI, VXI, LXI, and VISA - Bus protocols - HART, CAN, MOD, Fieldbus, and Profibus - IoT	
Unit-4 - Virtual Instrumentation for Signal Generation, Measurement, and Analysis	***9 Hour***
Signal/Function generator - Precision power supply - Multimeter - Mixed signal oscilloscope - Signal analysis – Max min, noise/jitter analysis, peak detection, zerocrossing, overshoot, and undershoot	
Unit-5 - Applications of Virtual Instrumentation	***9 Hour***
Importance of virtual instrumentation in mechatronics - Industrial applications of ON/OFF control and PID control - Virtual instrumentation in process control with a case study - Virtual instrumentation in machine vision with a case study - Healthcare, robotics, industrial applications of VI	

Learning Resources	1. *Jeffery Travis and Lisa K Wells, "LabVIEW for EVERYONE",Prentice Hall, Edition 2, 2002.* 2. *S. Sumathi, P. Surekha, "LabVIEW based Advanced InstrumentationSystems", Springer, 2007.* 3. *Mahesh L Chgani, Abhay R Samant and Michael Cerna, "LabVIEW signalprocessing", Pearson Education, 1998.*	4. *Kevin James, "PC Interfacing and Data Acquisition", Elsevier, 2002.* 5. *Lawrence M. Thompson and Tim Shaw, "Industrial Data Communications", ISA press, 5th Edition, 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%*	-	*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. Ganesh Ram, Intel Labs, Bangalore,*	1. *Dr. N.Pappa, MIT, Anna University*	1. *Dr. V.Sujatha, SRMIST*
2. *Mr. Mohammed Sagheer, WABCO Technology Center,India*	2. *Dr.P.Karthikeyan, MIT, Anna University*	2. *Mrs. G.Madhumitha, SRMIST*

Course Code	21MHE407T	Course Name	AUTONOMOUS MOBILE ROBOTICS	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:	*formulate the challenges in developing autonomous mobile robots*
CLR-2:	*abstract kinematic control of wheeled mobile robots*
CLR-3:	*understand the challenges involved in sensory perception for mobile robots*
CLR-4:	*understand the localization and path planning algorithms*
CLR-5:	*comprehend the challenges in implementing controllers, Comprehend the challenges in implementing controllers*

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:	*formulate the challenges in developing autonomous mobile robots*	*3*	*3*	*2*	*1*	*1*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*1*	*-*	*-*
CO-2:	*abstract kinematic control of wheeled mobile robots*	*3*	*3*	*2*	*2*	*1*	*-*	*-*	*-*	*2*	*1*	*-*	*1*	*-*	*2*	*-*
CO-3:	*understand the challenges involved in sensory perception for mobile robots*	*3*	*2*	*1*	*2*	*1*	*-*	*-*	*-*	*2*	*1*	*-*	*-*	*-*	*2*	*-*
CO-4:	*develop localization and path planning algorithm for mobile robot navigation*	*3*	*2*	*2*	*2*	*2*	*-*	*-*	*-*	*2*	*1*	*-*	*1*	*3*	*-*	*-*
CO-5:	*comprehend the challenges in implementing controllers, Build the required foundation for developing autonomous mobile robots*	*3*	*2*	*2*	*2*	*2*	*-*	*-*	*-*	*1*	*1*	*-*	*1*	*-*	*-*	*2*

Unit-1 - Introduction	***9 Hour***
Mobile Robots vs. Manipulators - Introduction to autonomous mobile robots - Locomotion aspects of mobile robots - Introduction to wheeled mobile robots- wheel types - Wheeled Configurations - Maneuverability, controllability, Stability of mobile robots - Wheeled Locomotion - Case studies - Degrees of freedom,differential degrees of freedom - Holonomic and non-holonomic systems- Kinematic constraints of a fixed standard wheel- Kinematic constraints of a omni-directional wheels	
Unit-2 - Kinematics and Dynamics of Mobile Robots	***9 Hour***
Forward kinematic models of three wheeled differential drive robot - Forward kinematics of a three wheeled omni-directional robot - Degree of Maneuverability- Mobility analysis of various wheeled configurations - Workspace and trajectory considerations - Comparison of maneuverability and controllability- State space modelling of three wheeled differential drive robot- Multi-rotor aerial robot, Types and applications- Modelling of Control of Quadrotor Aerial Vehicle-Introduction to Underwater vehicles- Modelling of dynamics of underwater vehicle	
Unit-3 - Sensors for Mobile Robots	***9 Hour***
Sensors for mobile robots - Characteristics applicable to mobile robots - Relating the characteristics to performance attributes of mobile robot - Physical and computational attributes of sensors applicable to mobile robots - sensor noise and sensor aliasing - GPS and heading sensors - Principles, challenges and interpretation Light and sound based ranging - Principles, challenges and interpretation -Wheel Odometry- Implementation algorithm for wheel odometry- Wheel Odometry Critical Analysis- Wheel Odometry error reduction- Vision for mobile robots- Introduction to Visual Odometry and V-SLAM- Multi-sensor combinations- Need and types	
Unit-4 - Mobile Robot Control	***9 Hour***
Robot Motion - Smoothing Algorithm, Path Smoothing - Zero Data Weight- PID - Implementation aspects of proportional control, integral control, derivative control: Systematic Bias - PID Tuning for autonomous mobile systems - Parameter Optimization: Go-goal Controller - Cruise Controller	
Unit-5 - Localization and Path Planning	***9 Hour***

- Introduction to localization, Localization challenges - Belief representations, Considerations in Belief representations & Map representations - Types, trade-offs -Introduction to Kalman filtering & Derivation of Kalman gain - Kalman filter and Extended Kalman Filter for localization - Sensor fusion using Kalman filter -Particle Filter Based Localization - Object Detection and Sensor Data Fusion Introduction to path planning, D Lite - Bug algorithms - Vector field histogram Collision avoidance algorithms*

Learning Resources	1. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.* 2. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition,Springer, 2016.* 3. *Perter Corke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017*	4. *Klancar, Gregor, et al. "Wheeled mobile robotics: from fundamentals towardsautonomous systes". Butterworth-Heinemann, 2017.* 5. *Sebastian Thrun, et al, "Probabilistic Robotics", MIT Press, 2006*

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, Japan*	1. *Dr. P. Karthikeyan, MIT Campus, Anna University,*	1. *Dr. K.Sivanathan, SRMIST*
2. *Mr. Elayraj Jayaraj, Apple, USA*	2. *Dr. Thiyagarajan, Indian Institute of Technology Tirupati.*	2. *Mr. J.Thiyagarajan, SRMIST*

Course Code	21MHE408L	Course Name	MEASUREMENT AND DATA ACQUISITION LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	impart knowledge on various programmable Test and Measuring Instruments
CLR-2:	acquire knowledge in understanding the concepts of simulation and apply for industrial automation
CLR-3:	familiarize simulation using PLC for different industrial applications
CLR-4:	incorporate knowledge on the real time controller for industrial automation
CLR-5:	explore the significance of FPGA based SOM controller

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 fundamentals of programmable Test and Measuring Instruments	3	-	2	-	3	-	-	-	-	-	-	2	-	2	-
CO-2:	interpret the significance of programming and simulation for industrial automation	3	-	2	-	3	-	-	-	-	-	-	2	-	2	-
CO-3:	develop simulation using PLC for different industrial applications	3	-	3	-	3	-	-	-	-	-	-	2	-	2	-
CO-4:	exposed to real time controller and its applications	3	-	3	-	3	-	-	-	-	-	-	2	-	2	-
CO-5:	build interfacing of FPGA based SOM controller for different industrial applications	3	-	3	-	3	-	-	-	-	-	-	2	-	2	-

Unit-1 - Programmable T&M Instruments — **15 Hour**

Sampling and Quantization and Oscilloscope Triggering Basics, Measurements, auto-masking and error finding techniques, Understanding Frequencies and filtering, Storage and Retrieval, trigger measurements, eye plots, Special features of Digital Storage Oscilloscope, SMPS Testing with Oscilloscope, Working with arbitrary waveform generator, Working with digital signals and MSO features, Understanding ADC with MSO, Working with bench-top DC power supplies, Characterizing power supply using oscilloscope, PC connectivity of programmable instruments using VISA, Data Logging with programmable instruments, Closed loop system building with programmable instruments

Unit-2 - Industrial Automation Simulation — **15 Hour**

Getting started with GUI of 3D Industrial Automation Simulation Software, Basic PLC programming with MPS stations, Advanced PLC programming with MPS Transfer Systems, Robot aided pick and place, Robot aided palletizing, Robot aided assembly station without PLC, Robot aided assembly station with PLC, Robot aided punching station with PLC, Robot aided punching station without PLC, Robot aided assembly and punching station integration with PLC, Robot aided assembly and punching station integration without PLC,Micro FMS programming

Unit-3 - Programmable Logic Controllers — **15 Hour**

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

Unit-4 - Industrial Real Time Controller — **15 Hour**

Introduction to FPGA programming using high-level programming language, Modes of Using Reconfigurable Hardware – RT, FPGA and Scan Engine, Programmatic launching of applications, Communication between real-time microcontroller and FPGA – DMA FIFO, Communication between real-time microcontroller and FPGA – Interrupt Based, Time stamping in FPGA, Hardware Triggering for Image Acquisition, Socket Communication between devices with Real-Time Microcontroller, SPI Communication, I2C Communication, RS232/RS422/RS485 Using VISA, RS232/RS422/RS485 in FPGA, CAN Interfacing, Hardware-in-loop Simulation with Real Time Controllers

Unit-5 - FPGA Based SOM Controller	***15 Hour***
Getting started with SOM and Basic Programming, Development methodologies, Rotary Encoder Decoding, Closed Motor Speed Control, TOF Sensor based DC Motor Control, RGB OLED Display and Key Pad Interfacing, 9-axis IMU Interfacing, Two-axis Joystick based dual motor control, Wifi and Bluetooth Communication, Image Acquisition – Synchronous and Asynchronous Modes, R/C servo based Pan-tilt gimbal control, Visual tracking using R/C servo based Pan-tilt gimbal, Creating custom overlay, Creating custom function accelerator, Deep learning inference using FPGA	

Learning Resources	1. *Juan Jose Rodriguez Andina, Eduardo de la Torre, Maria Dolores Valdes, FPGAs Fundamentals, Advanced Features, and Applications in Industrial Electronics, CRC Press, 2020* 2. *Richard L. Shell and Ernest L. Hall, Handbook Of Industrial Automation, CRC Press, 2000* 3. *Peng Zhang, Advanced Industrial Control Technology, William AndrewPublishing, 2010.*	4. *Max Rabiee, Programmable Logic Controllers: Hardware and Programming, Goodheart-Willcox, 2017* 5. *Clyde coombs, Electronic Instrument Handbook, McGraw-Hill Professional, 1999.* 6. *Chanchal Dey, Sunit Kumar Sen, Industrial Automation Technologies, CRC Press, 2020.* 7. *Bruno, Frank, FPGA programming for beginners, Packt Publishing, 2021.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Shankar Bharathi, L&T Technology Services,*	1. *Dr. R. Thiyagarajan, IIT Tirupati, thiyagu@iittp.ac.in*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Mohammed Sagheer, WABCO Technology Center, India*	2. *Dr. G. Nagamanikandan, IIIT Hyderabad*	2. *Dr. S.Vasanth, SRMIST*

Course Code	21MHE409T	Course Name	ADVANCED MICROCONTROLLERS AND SIGNAL PROCESSORS	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:	*provide fundamental knowledge of digital signal controller*
CLR-2:	*familiar with the architecture and basic programming of dsPIC 30*
CLR-3:	*familiar with architecture and basic programming of Msp430*
CLR-4:	*provide communication interfacing of Msp430*
CLR-5:	*provide real-world applications of controller*

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:	*describe the basic concepts of Digital signal controller*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*program dsPIC30*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-3:	*program Msp430*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the programming knowledge of the Msp430 to communication interface*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-5:	*apply the theory and programming of dspic30 and Msp430 to solve mechatronics related problems*	*2*	-	-	-	*1*	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Overview of Digital Signal Controllers	***9 Hour***
C2000 MCU, Piccolo MCU, Delfino based controllers, dsPIC 30F series DSC, MAC units, hardware divide support, floating point signal processing support.	
Unit-2 - Introduction to dsPIC 30F	***9 Hour***
dsPIC 30F series – Introduction to 16 bit microcontrollers: dsPIC 30F – CPU, data memory, program Memory, instruction set. Programming using XC16 compiler and C-Interrupt Structure.Peripherals of dsPIC30F: I/O Ports, timers, input capture, output compare, motor control PWM, 10 bit A/D converter, UART-,programming	
Unit-3 - Introduction to MSP430	***9 Hour***
MSP430 Architecture, CPU Registers, Instruction Set, addressing modes, the MSP430 family viz. MSP430x2x, MSP430x4x, MSP430x5x. MSP430f2274 – MSP430X22X2 device pin out, DA Package, Functional Block diagram description, Inputs, Outputs, Timers, ADC-programming	
Unit-4 - Peripheral Interface of MSP430	***9 Hour***
Serial and Parallel Communication, Synchronous and Asynchronous Interfaces, Implementing and Programming of: UART, I2C and SPI Protocol. Wireless Connectivity: NFC, Zigbee, Bluetooth and Wifi. Msp430 Development Tools.	
Unit-5 - Case Studies	***9 Hour***
Applications using dsPIC30F: Generating SPWM, generating PWM's for power converters, PID based control loops. Automatic Temperature Controller Applications of MSP 430 : Implementing Wifi Connectivity, MSP430 based Supervisory & MPPT system	

Learning Resources	1. *John H. Davies, "MSP 430 Micro controller basics", Elsevier, 2008. dsPIC 30F, Reference Manual, Microchip*	2. *Chris Nagy, "Embedded System Design using the TI MSP 430 Series", FirstEdition, Newnes, 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*	*40%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*60%*	-	*60%*	-	*60%*	-
Level 3	*Apply*	-	-	*20%*	-	*20%*	-
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. K. Karthikeyan, Hitachi Energy, Bangalore*	1. *Dr.T.Balakumaram , Institute of Technology,Coimbatore*	1. *Dr.S.Vani, SRMIST*
2. *Mr. SathiyaMoorthi, Broadcom Inc,*	2. *Dr.S.Srinivasan, Saveetha University, Chennai*	2. *Dr.M.Mohamed Rabik, SRMIST*

Course Code	21MHE410T	Course Name	MACHINE VISION AND IMAGE PROCESSING	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:	*incorporate knowledge on the machine vision technology as a tool for industrial automation*
CLR-2:	*acquire knowledge in understanding the specification of vision hardware*
CLR-3:	*develop a comprehensive understanding of the fundamental algorithms and implement them*
CLR-4:	*develop proficiency in applying image processing algorithms to industrial problems*
CLR-5:	*acquire an introductory information related to 3D vision and deep learning techniques*

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 properties of light which defines the possibilities and limitation of a vision system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*creates interpretation of various specification of an imaging system to select the right hardware based on the understanding of scene constraints*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*develop algorithm to enhance images*	-	*2*	*2*	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*develop algorithm that extract various types of attributes from digital images*	-	*2*	-	*2*	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze the application of various 3D vision techniques and deep learning techniques*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Fundamentals of Lighting	***9 Hour***
Physics of light - Imaging modalities with light - Interactions of light - Reflection and Refraction - Related fields and Industries using vision - Introduction to machinevision system building - Task specification - Design of the system - Cost calculation - Development, Testing and Commissioning - Human visual system – Comparison with a machine vision system - Scene Constraints - Light sources - Lighting Techniques, types and selection.	
Unit-2 - Imaging System	***9 Hour***
Machine vision lenses - Filters - Image sensor specifications, terminologies - Sensor types based on sensing element - selection criteria - Camera computer interfaces, types and section - Camera parameters governing geometrical image formation - Camera modeling - Camera Calibration - Distortions.	
Unit-3 - Image Processing	***9 Hour***
Machine vision software - selection criteria - Basics of digital image - Sampling and Quantization - Gray scale histogram - Thresholding - Contrast stretching – Image smoothening, sharpening, edge detection in spatial domain - Derivative operators - 2D discrete Fourier transform - Frequency domain processing for image smoothening and sharpening - Low and high pass filters - Binary morphology - Basic morphological operations - Non-linear filters - Color image processing.	
Unit-4 - Image Analysis	***9 Hour***
Feature extraction - Region features - Template matching - Methods of template matching - Linear classification - Corner detection - Harris corner detection - Keypoint matching - Matching methods - Texture Analysis - Approaches and methods - Co-occurrence Matrix - Properties of Co-occurrence matrix – Decision making considerations for various machine vision applications.	

Unit-5 - 3D Vision & Deep Learning	***9 Hour***
Classification of 3D vision techniques - Active vision -LiDAR - Computational Stereo Vision - Steps in Stereo vision - Introduction to Neural networks - Types of neural networks - Back propagation learning - Numerical problem - Concepts in Machine learning - Convolutional layer of neural network - Numerical - Convolutional neural network for image classification - Architecture details - Object detection using CNN - Single shot learning for object detection.	

Learning Resources		
	1. *Gonzalez, R. C., & Woods, R. E., "Digital Image Processing", 2018edition, Pearson.* 2. *Hornberg, A., "Handbook of Machine Vision", 2015 edition, Wiley-VCH.* 3. *Hecht, E., "Optics", 2016 edition, Pearson.*	4. *Trucco, E., & Verri, A., "Introductory Techniques for 3D Computer Vision", 1998edition, Prentice Hall.* 5. *Goodfellow, I., Bengio, Y., & Courville, A., "Deep Learning", 2016 edition, MITPress.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Mohammed Sagheer, Wabco Technology Center,*	1. *Dr. R. Thiyagarajan, Indian Institute of Technology Tirupati,*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Shankar Bharathi, Larsen & Toubro TechnologyServices,*	2. *Dr. P. Karthikeyan, MIT Campus, Anna University,*	2. *Mr. S. M. Vignesh, SRMIST*

Course Code	21MHE411T	Course Name	APPLIED MECHATRONICS SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the design process and integrated design issues in mechatronics system*
CLR-2:	*acquire the knowledge of Mechatronics in mobility*
CLR-3:	*apply the concept of Mechatronics in manufacturing*
CLR-4:	*acquire the knowledge of Mechatronics in medical and sports*
CLR-5:	*apply the concept of Mechatronics in construction and bio mimics robot*

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 of Various simulation based on the applications*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*build a mechatronics system for mobility applications*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*develop a mechatronics system for manufacturing applications*	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*create a mechatronics system for medical and sports applications*	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*develop a mechatronics system for construction and bio mimics robot applications*	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Mechatronics	***9 Hour***
Definition of mechatronics - Evolution of mechatronics systems - Multidisciplinary nature of modern machines and their design challenges - Traditional vs mechatronics approaches - Mechatronics design process - Need of design tools integration - Review of key elements of mechatronics systems from integration perspective - Role of mechatronics engineer - Various steps for design - Types of design (mechatronics approach) - integrated product design - load conditions on mechanisms - Structure and systems - Man Machine Interface (MMI) - Mechatronics design concept and framework - overview of mechatronics key elements definition of mechatronics: sequential integration and concurrent integration - integrated design issues in mechatronics - Introduction to real time interfacing elements of data acquisition and control system - transducer and signal conditioning - devices for data conversion - data conversion process - HMI design process - designing human-automation interaction - human error, interaction and the development of safety critical systems	
Unit-2 - Mechatronics in Mobility	***9 Hour***
Need of mechatronics in automobiles. modelling and simulation antilock braking system – power steering – adaptive cruise control – active suspension system – case studies in vehicle communication - Hybrid EV- electronic ignition – engine control system – tyre pressure monitoring system - Ornithopter – Intelligent cockpit electronics – Digital flybywire systems- longitudinal and later control design – surveillance drone – Navigation – Robotic arm in International Space station- Magnetic levitation system	
Unit-3 - Mechatronics in Manufacturing	***9 Hour***
Computed aided metrology — monitoring and control in manufacturing process - case studies in additive manufacturing - case studies in advanced machining-case studies in automated production line - AGV - simultaneous localization and mapping(SLAM) -virtual manufacturing -internet controlled manufacturing - SMART FACTORY, ASRS, mobile manipulator	
Unit-4 - Mechatronics in Medical and Sports	***9 Hour***
Surgical Robot - Skeletal muscles servo mechanism – Analysis of force in orthopedic implants – sensory assisted exoskeletons – lower and upper limb exoskeleton- Rehabilitation, wheelchairs for mobility assistance - Haptics- online patience monitoring - Applications in sports and exercise .	

Unit-5 - Mechatronics in others Application	***9 Hour***
Intelligent safety elements in buildings - robotics in construction – IoT assisted home automation- Bio Mimics Robot - snake robot, fish robot, ornithopter - Inverted pendulum - Vending machines	

Learning Resources	1. *Robort H Bishop, "Mechatronics an Introduction", Taylor andFrancis, 2nd edition, 2003.* 2. *Annalisa Melilla, Donato Di Paola and GraziaCicirelli, "MechatronicSystems, Applications", InTech publisher, 2010.* 3. *Bolton, "Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering", 4th edition, Addison Wesly Longman Ltd.,*	4. *Devdasshetty, Richard A. Kolkm, "Mechatronics System Design", PWS Publishing company, 2nd edition, 2010.* 5. *M. D. Singh, J. G. Joshi, "Mechatronics", Prentice Hall of India Private limited, 2006.* 6. *William B. Ribbens, Norman P. Mansour, "Understanding Automotive Electronics", 6th edition, Elsevier Science, 2013.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. C. Elan Chezhian, Keyence Engineering, Chennai*	1. *Dr. D. Saravanakumar, VIT University, Chennai*	1. *Dr. T. Muthuramalingam, SRMIST*
2. *Dr. K.P. Srinivasan, Mahindra Research Valley,Chennai*	2. *Dr. P. Karthikeyan , MIT, Anna University, Chennai*	2. *Mr. A. Lakshmi Srinivas, SRMIST*

Course Code	21MHE412T	Course Name	REAL-TIME EMBEDDED SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21MHC205J	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:	*think and evolve with the basic of Embedded System that can be converted to a system design*
CLR-2:	*perceive the concept of interrupt, memory that can be evolved to real time environment*
CLR-3:	*know the functions and scheduling of RTOS towards a system design*
CLR-4:	*learn the different approaches and scheduling real time characteristics with specific algorithms*
CLR-5:	*know different communication types and protocols for specific applications*

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:	*translate the requirements of embedded system to a system design*	*1*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply correctly the terminology to the real time environment*	*1*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*explain the structure of real time operating system*	*1*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*translate the approaches related to the real time characteristics application*	*1*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*interface hardware with communication protocol*	*1*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Embedded System — ***9 Hour***

Introduction to the course and Discussion- Embedded computers, Characteristics of embedded computing, challenges in embedded computing system Design- Embedded System Design Process: Requirement, Specifications-Architecture Design-Designing of software and hardware Components-System Integration- Formalism for System Design: Structural Description-Design Example: Data compressor, Alarm clock

Unit-2 - Interrupts in Embedded System — ***9 Hour***

Terminologies of an Embedded System-Gates and timing diagram-Memory and its Types-Microprocessor Buses-Programming the input and output devices- Direct Memory Access-Interrupts: Built Interrupts-Supervise mode, Exceptions and Traps-Shared Data Problem-Disadvantage of interrupt Latency-Embedded system evolution Trends-Interrupt routines in an RTOS environment-Real Time Clock-System Clock

Unit-3 - Overview of RTOS — ***9 Hour***

Introduction -Multiple task and Multiple processes: Task and Processes, Multi-rate systems, Timing requirements on the process, CPU metrics-Process state and scheduling-Scheduling policies-Running periodic process-RTOS task and task state-Pre-emptive Real-time operating systems- Multithread pre-emptive schedule-Priority based scheduling: Introduction and its types-Rate-Monotonic scheduling-Earliest Deadline First scheduling-Evaluation of operating systems performance-Design of Telephone answering machine

Unit-4 - Real-Time Characteristics — ***9 Hour***

Introduction to real-time Characteristics-Algorithm: Clock drive approach-Weighted round robin approach-Priority driven approach-Example for priority-driven approach-Dynamic versus Static System-Effective release times and deadline-optimality of the Earliest Deadline First(EDF) Algorithm-Real time concepts of EDF-Challenges in validating timing constraints in priority-driven systems- Off-line versus online scheduling

Unit-5 - Communication Interfacing — ***9 Hour***

Introduction to converters and their Types-Types of ADCs and DACs, Working Principle-Introduction programmable interface with A/D and D/A-Introduction and Working principle of Control Robot System-Introduction and working principle of Pulse Width Modulation-Introduction and working principle of motor speed Controller-Serial and parallel Communication-Wireless Communication-Serial Protocols: I2C, CAN and USB-Parallel Protocols: PCI and ARM Bus-Wireless Protocols: IrDA, Bluetooth and IEEE 802.11

Learning Resources	1. *Payne Golf, 'Computers as Components: Principles of Embedded Computing System Design", Morgan Kauffman Publishers,2011* 2. *Frank Vahid and Tony Givargis," Embedded System Design: A Unified Hardware/Soft 'are Introduction', John Wiley and Sons, 2002.* 3. *David Simon, "An Embedded Software Prime Pearson EducationAsia, 2001.*	4. *Raj Kamal," Embedded Systems', Tata McGraw Hill,2009* 5. *NPTEL Engineering Mechanics Lectures by IIT Guwahati 'https://nptel.ac.in/courses/112103109/*

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, Hitachi Energy, Bangalore*	1. *Dr N V Uma Reddy, New Horizon College of Engineering, Bengaluru*	1. *Dr Mohamed Rabik, SRMIST*
2. *Ms. Mageshwari Dilip, Freshworks private Ltd, Chennai*	2. *Dr.K.Balasubadra, RMD Engineering College, Chennai.*	2. *Dr B.Priya Esther, SRMIST*

Course Code	21MHE413T	Course Name	CONDITION MONITORING TECHNIQUES	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:	*learn the fundamentals and need of condition monitoring*
CLR-2:	*understand the monitoring various mechanical parameters*
CLR-3:	*realize the monitoring in manufacturing*
CLR-4:	*learn about the computational surface reconstruction*
CLR-5:	*acquire the knowledge on AI for manufacturing*

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:	*selection of suitable control and data acquisition*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*gaining the knowledge of various monitoring techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*obtaining the knowledge of surface defects*	-	*3*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*implementation of various surface reconstruction based on application*	-	*3*	-	*2*	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*gaining the knowledge of AI fin manufacturing*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Need of Condition Monitoring — ***9 Hour***

Importance and necessity of maintenance, different maintenance strategies - principles of condition monitoring - Concept and metrics of condition monitoring - Selection and scope of computerization – Basic control systems - Computer process control - Fundamentals of data acquisition - Basic signal processing techniques - transducers for condition monitoring, NDT methods in condition monitoring

Unit-2 - Systems and Temperature Monitoring — ***9 Hour***

Need of Fourier analysis, Hilbert Transform, Digital filtering, Deterministic / random signal separation , Wavelet Transform - Time-frequency analysis –- Simple temperature measurement techniques - Pyrometry and infrared line scanners - Thermal imaging or thermo graphic systems - System Condition monitoring case studies-techniques -visual monitoring, temperature monitoring, vibration monitoring, crack monitoring, thickness monitoring, noise and sound monitoring

Unit-3 - Condition Monitoring in Manufacturing — ***9 Hour***

Vibration Monitoring, vibration data collection, techniques, transducers, selection, measurement location, commonly witnessed machinery faults diagnosed by vibration analysis - Measurement of surface and subsurface flaws –liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection - AE based crack analysis – Adaptive control in CNC

Unit-4 - Computational Surface Reconstruction Techniques — ***9 Hour***

Shape from texture, focus, defocus- Geometry, parameters – feature extraction – surface profile measurement using both touch and non-touch sensory information – surface profile measurement using image processing – tool wear analysis during image processing

Unit-5 - Application of AI in Monitoring — ***9 Hour***

Artificial Intelligence, Fuzzy Logic, Genetic Algorithms Neural Networks for Intelligent Process Monitoring and Control : Applications to CNC machining, Metal Forming - Intelligent Manufacturing Planning, Scheduling and Control - Applications to web based CAD, CAPP, CNC, Assembly planning, and Rapid Prototyping

Learning Resources	1. *Dagli, C.H., "Intelligent systems in design and manufacturing",ASME, 1994.* 2. *Boguslaw Cyganek, J. Paul Siebert, An Introduction To 3D Computer Vision Techniques and Algorithms, First Edition, 2009.* 3. *Juan Carlos Jauregui Correa, Alejandro Lozano Guzman, MechanicalVibrations and Condition Monitoring, 1st Edition, 2020*	4. *Rao J.S. "Vibratory Condition Monitoring of Machines" CRC Press. 2000* 5. *Davis A. "Handbook of Condition Monitoring Techniques and Methodology"Springer. 1998* 6. *Don Nyman and Joel Levitt, Maintenance Planning, Scheduling andCoordination, Industrial Press Inc., New York, 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. *Mr. C. Elan Chezhian, Keyence Engineering, Chennai*	1. *Dr. G. Sakthivel, VIT University, Chennai*	1. *Dr. G. Murali, SRMIST*
2. *Dr. K.P. Srinivasan, Mahindra Research Valley,Chennai*	2. *Dr. P. Karthikeyan , MIT, Anna University, Chennai*	2. *Dr. T. Muthuramalingam, SRMIST*

Course Code	21MHE414T	Course Name	ADVANCED CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21MHC301T	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:	explicit the continuous domain control systems as digital domain systems
CLR-2:	evaluate the inspect the stability of non-linear systems
CLR-3:	estimate the concept of robust control system
CLR-4:	construct an optimal control system
CLR-5:	design of an optimal estimator

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:	express a control system in discrete format	3	2	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-2:	analyze and depict the stability of Non-linear system	3	2	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-3:	design a Robust Controller	3	2	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-4:	accomplish an optimal controller	3	2	3	-	2	-	-	-	-	-	-	-	3	-	2
CO-5:	contemplate an optimal estimator	3	2	3	-	2	-	-	-	-	-	-	-	3	-	2

Unit-1 - Discrete Time Control System	**9 Hour**
Introduction to sample data systems, Sample and hold process, Zero and first order control systems, Transfer function of discrete time systems, Performance of sample-data second order system, Stability Analysis of discrete -time systems-Jury's stability criteria, Digital control design, Mapping of s-plane and z-plane, Implementation of digital compensators by direct digital methods.	
Unit-2 - Non-Linear Control	**9 Hour**
Non-Linear dynamics, Common Physical Nonlinearities Concept of phase plane Analysis, Phase Portraits, Singular Points, Symmetry in Phase plane portraits, Non-linear Systems, Equilibrium Points, Stability Analysis, Lyapunov's Stability criterion for Linear and Non-Linear Systems, Construction of phase plane trajectories, Describing function of common Nonlinearities, stability analysis by describing function	
Unit-3 - Robust Control	**9 Hour**
Robustness, sensitivity, Analysis of Robustness in System parameters, Robust control systems, Design of Robust control systems, Robust PID control system and its design, Internal Model control system and its robustness, Pseudo-Quantitative Feedback Systems and its design, Model Predictive control overview	
Unit-4 - Optimal Control	**9 Hour**
Principle of optimality, Dynamic Programming, Hamilton-Jacobi-Bellman Equation, Calculus of Variations Pontryagin's Minimum Principle, Bang bang control, Linear Quadratic Regulator design, Continuous and Discrete Riccati Equation Forms, H2 and H-Infinity Optimal Control, Basics of Convex Optimization, Receding Horizon Principle	
Unit-5 - Optimal Estimation	**9 Hour**
Overview of Stochastic Processes, Probability and Random Variables, Spectral Analysis of stochastic Process Special cases: Mutivariate Normal distribution, Kalman filters-Continuous and discrete, Variants of Kalman Filter, Extended Kalman Filter, Unscented Kalman Filter, Linear Quadratic Gaussian (LQG) control Problem, LQG design and implementation	

Learning Resources	1. *M.Gopal, Digital Control and State Variable Methods: Conventional and Intelligent Control System McGraw Hill 3rdEdition, 2008* 2. *Richard C Dorf and Robert H Bishop, "Modern Control Systems", 13th edition, Pearson Education, 2016.* 3. *Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015.*	4. *Roland S. Burns, Advanced Control Engineering, Butterworth-Heinemann, First edition, 2001* 5. *Deseneni, Subbaram Naidu, "Optimal Control Systems", 1st edition, CRCPress, 2003.* 6. *Jean-Jacques E Slotine, Weiping Li, Applied Nonlinear Control", PrenticeHall of India-New Jersey, 1991*

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, Hitachi Energy, Bangalore*	1. *Dr.M.Mythili, Assistant Professor, Department of Electronics and Instrumentation Engineering, Anna University, Chennai – 600025.Email – mythilym@annauniv.edu.in*	1. *Dr. M. Mohamed Rabik, SRMIST*
2. *Mr. Emmanuel T, AI Innovations Pvt Ltd*	2. *Dr.P.Karthikeyan, Assistant Professor, Department pfProduction Technology, Anna University, Chennai- 600044. Email id:pkrthikeyan@mit.edu*	2. *Mrs. D. Sasikala, SRMIST*

Course Code	21MHE415T	Course Name	MICRO ELECTRO MECHANICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart knowledge of behavior of mechanical and electrical elements at micro level*
CLR-2:	*identify the MEMS materials and their preparation*
CLR-3:	*emphasis on electrical and Thermal actuation in microsystems*
CLR-4:	*emphasis on Piezoelectric and Magnetic actuation in microsystems*
CLR-5:	*expose on MEMS applications in Automotive sector and Introduce computer aided simulation of microsystems*

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 behavior of MEMS systems*	*3*	*1*	-	*1*	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*understand the operation and manufacturing of microsystems and Solve problems in scaling laws applicable to miniaturization*	*3*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*design micro sensors and actuators actuated by electrical and Thermal actuation*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*design micro sensors and actuators actuated by Piezoelectric and Magnetic actuation*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*gain knowledge on different applications of MEMS devices and Simulate simple Microsystems*	*3*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Mechanical and Electrical Conceptions — ***9 Hour***

Elements of MEMS, Silicon as a MEMS material – mechanical properties of silicon, General scalar relationship between stress and strain, Study of Flexural beams bending under simple loading conditions, Mechanical deformation of cantilever beam spring, Deformation of torsional bars, Discussing the Simple problems related to force constant, Origin of intrinsic stress, Methods for characterization, Damping & Quality factor, Resonant Frequency, Active Tuning of spring constant and resonant frequency

Unit-2 - Microsystems Fabrication Processes — ***9 Hour***

Scaling Law of Miniaturization, Materials for MEMS: Silicon, Silicon Compounds and Polymers, Microsystem Fabrication Processes: Photolithography, Ion Implantation, Diffusion, Oxidation, Chemical Vapor Deposition (CVD), Physical Vapour Deposition (PVD), Surface micromachining, LIGA Process, Bulk micromachining; Dry etching, Wet etching, Plasma etching, DRIE, MEMS process integration strategies, Microsystem Packaging, Design of micro-channel heat sink: Application of micro-channel heat sink

Unit-3 - Electrostatic, Capacitive, Thermal Sensing and Actuation — ***9 Hour***

Electrostatic sensors and actuators, Parallel plate capacitors, Equilibrium position of parallel plate actuators, Pull-in effect of parallel plate actuators, Applications of Parallel plate capacitors, Inertia sensor, Pressure sensors, Flow sensors, Tactile sensors, Parallel plate actuators, Interdigitated Finger capacitors, Comb drive accelerometer, Thermal Sensing and Actuation, Thermal resistance, Thermal bimorph principle, Thermal bimorph actuator, Accelerometer based on thermal transfer, Thermal accelerometer with no moving mass, Flow sensors based on thermal transfer principle, Infrared sensor, Micro Sensors: Acoustic wave sensors, Biomedical sensors and Biosensors

Unit-4 - Piezoresistive, Piezoelectric, Magnetic Sensing and Actuation — ***9 Hour***

Piezo resistivity gauge factor, Piezoresistive materials, Applications of piezoresistive sensor, Inertia sensors, pressure sensors based on piezo resistivity, Tactile sensor, Flow sensor,Piezoelectric sensing and actuation, Piezoelectric materials, Piezoelectric Accelerometer, Magnetic actuation, Essential concepts and principle, Deposition of Magnetic materials, Fabrication of Magnetic coil, Magnetic motor, Magnetic beam actuation, Micro grippers

Unit-5 - MEMS Case Studies	***9 Hour***
MEMS inertial sensor in automobile airbag deployment, MEMS vibratory gyroscope, Optical MEMS, MEMS devices in space exploration, Micro power sources, Power MEMS,MEMS-based medical applications such as drug delivery systems (DDS) and defibrillators, Capacitive accelerometer Exposure to commercial software, Model preparation using COMSOL Multiphysics, IntelliSuite, CoventorWare, MEMS Plus, and ANSYS, modelling and simulation of mems actuator(piezoelectric) and mems sensor(accelerometer)	

Learning Resources	1. *Tai- Ran Hsu, "MEMS and Microsystem Design and Manufacture" McGraw HillEducation (India) Private Limited, New Delhi, 2002* 2. *Chang Liu, "Foundations of MEMS" 2nd edition, Dorling Kindersley India PvtLtd, 2012* 3. *Rai-Choudhury.P., "MEMS and MOEMS Technology and Applications" PrenticeHall of Indian Indian Learning Private Limited, 2009* 4. *NadimMaluf, "An Introduction to Microelectromechanical Systems Engineering"2nd Edition, Artech House, 2004*	5. *Reza Ghodssi, Pinyen, "MEMS Materials and Processes Handbook", Springer Science Business Media, 2011.* 6. *Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices and Structures" CRC Press, 2002.* 7. *Julian W.Gardner, Vijay.K.Varadhan, Osama.O.Awadelkarim, "Microsensors, MEMS and Smart Devices", John Wiley & Sons, LTD,2013* 8. *8.G.K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K.N. Bhat and V.K. Athrae, "Micro and Smart System", Wiley India Pvt Ltd, First edition, 2010*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *.Mr. Bruce Antonyappan,PROVIS,Qatar,*	1. *Dr.P.Sweety Jose, PSG College of Technology, Coimbatore*	1. *Dr.M.Belsam Jeba Ananth, SRMIST*
2. *Mr. Raju Samuel, Jurong Engg Limited, Singapore*	2. *Dr.N.Sudhakar ,VIT University, Chennai*	2. *Dr.S.Vani.SRMIST*

Course Code	21MHE416T	Course Name	GEOMETRIC MODELLING	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:	*comprehend the fundamentals of Graphics and transformations*
CLR-2:	*familiarize Knowledge in modelling of CAD system*
CLR-3:	*learn the various algorithm used in geometric modelling*
CLR-4:	*understand the mathematical concept of Model assembly for a machine elements*
CLR-5:	*learn computer graphics standards*

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:	*gain knowledge in fundamentals of Graphics and transformations*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*impart Knowledge in modelling of CAD system*	*3*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply various algorithm used in geometric modelling*	*3*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*implement Model assembly for a machine elements*	*3*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*distinguish data exchange standards and common file types in CAD*	*3*	-	-	-	-	*3*	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to CAD ***9 Hour***

Design as a process, sequential and concurrent engineering. Computer-Aided Design (CAD) and its architecture. Transformation types: Two and three- dimensional. Algorithms: Line, circle, Clipping algorithm. Windowing and viewing.

Unit-2 - Curves, Surface, and Solids ***9 Hour***

Introduction to geometric modeling, Representation of synthetic curves, Surface and solid: Hermite curve, B-spline curves, Bezier curve

Unit-3 - Techniques of Geometric Modelling ***9 Hour***

Hidden line removal: Visibility of object views, Visibility of object techniques, Sorting & Coherence, Priority, and area orientation. Hidden surface removal: Back face, Scan line, Z-buffer, and Warnock's Algorithm. Hidden solid removal: Ray-tracing algorithm, Shading: Model, surface, Enhancement, solid. Coloring: Models, Types Animation: Conventional, Computer & Engineering Animation Types and Techniques, Morphing: Types and mode

Unit-4 - Assembly Modelling ***9 Hour***

Assembly modeling: Introduction, Part modeling, Representation of Hierarchical relationship & Mating Condition, Types of Approach Interferences of positions Tolerance: Introduction, need& concept of conventional Fits and Limits: MMC, LMC Modelling Worst-case and Manufacturing Tolerance analysis: Worst-case arithmetic and Worst- case statistical method, Monte Carlo simulation method Mass property calculations: First and second Moment of inertia Geometrical property: Curve Length, Surface Area : Volume: & Cross section Area

Unit-5 - Computer Graphics Standards ***9 Hour***

Computer graphics: Introduction, software, and Database CAD Graphics Translator: Types of Software standards: Graphical Kernel System (GKS) Exchange Database: IGES, STEP Drawing Exchange Format & ACIS Graphics Functions: Output Primitives Graphics Functions: Output Primitives Line attributes: types width, color Curve attributes: Color, table & Grayscale levels Area Fill Attributes: Style, pattern, soft Character Attributes: Text, Marker Processors: Design and Implementation Processors: Error handling, testing, and verification, Open Graphics Library (OpenGL): Introduction, Types

Learning Resources	1. *Ibrahim Zeid, "Mastering CAD CAM", Tata McGraw-Hill PublishingCo, 2007.* 2. *Chris McMahon and Jimmie Browne, "CAD/CAM Principles", Practice and Manufacturing Management 2nd edition, Pearson Education, 1999.* 3. *William M Neumann and Robert F.Sproul, "Principles of Computer Graphics", McGraw-Hill Book Co. Singapore, 1989.*	4. *Donald Hearn and M. Pauline Baker, "Computer Graphics", PrenticeHall, Inc, 1992.* 5. *Foley, Wan Dam, Feiner and Hughes, "Computer Graphics Principles andPractice", Pearson Education, 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%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*20%*	*-*	*15%*	*-*	*15%*	*-*
Level 3	*Apply*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*15%*	*-*	*15%*	*-*
Level 6	*Create*	*10%*	*-*	*15%*	*-*	*15%*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mrs.A.Priya ,Senior Principal Engg, Technip FMC,Chennai*	1. *Dr.S.Neelavathy Pari, Associate Professor,MIT,neela@annauniv.edu, Chennai.*	1. *Ms.D.Gayathiri, SRMIST*
2. *Mr.Ak.Lakshminaraimhan, Associate chief EngineerEngineer,Technip FMC AK, Chennai*	2. *Dr.R.Sarala, Associate Professor, Alagappa Chettiar college of Engineering and Technology, karaikudi, r.sarala@accetedu.in,*	2. *Mr.J.Arivaarasan , SRMIST*

Course Code	21MHE417T	Course Name	INDUSTRIAL AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*learn the need of Industrial Automation and characteristics of the Automation systems components*
CLR-2:	*understand the construction, operation and installation of PLCs*
CLR-3:	*impart the knowledge on various elements in SCADA System and various communication Networks systems*
CLR-4:	*gain knowledge on operator and engineering interface in DCS*
CLR-5:	*acquire the knowledge on Modelling for Advanced Process control and Model Based System Engineering*

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 Benefits of Industrial Automation and characteristics of the Automation systems components*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*
CO-2:	*develop PLC programs using various functions and operations of PLCs for a given application*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-3:	*illustrate the remote terminal unit and master terminal unit in SCADA Systems*	*-*	*2*	*2*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*
CO-4:	*apply the knowledge of DCS on Human machine interface and display interface systems for given applications*	*-*	*2*	*-*	*3*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*-*
CO-5:	*gaining the knowledge on Modelling for Advanced Process control and Model Based System Engineering*	*3*	*2*	*-*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*

Unit-1 - Industrial Automation in Production Systems	***9 Hour***
Introduction of industrial Automation, Need of Industrial Automation , Benefits , Basic components of Automation systems, History and Evolution of Industrial Automation, Levels of Automation ,Types and Characteristics of Automation systems, Applications of industrial Automation- transfer mechanisms, Material handling systems, storage systems and Automated Guided Vehicles systems ,Advanced Automation systems , Different systems for industrial Automation –PLC, HMI, SCADA,DCS,DRIVES	
Unit-2 - PLC Architecture and Applications	***9 Hour***
Principles of PLC Operations, PLC Architectures and Specification – PLC Programming, Ladder diagram ,Converting simple relay ladder diagram into ladder diagram, simple instructions- types of operated switching devices- Manual operated, Mechanical operated switching devices, Timer instructions, Data Manipulating, Math Instructions, Application of PLC, Hands on learning from industry or case studies	
Unit-3 - SCADA System and Architecture	***9 Hour***
Data Acquisition systems , Evolution of SCADA, Communication Technologies, Monitoring and supervisory control functions, SCADA Applications in utility Automation ,SCADA System Components in Industries: Schemes -Remote Terminal Unit (RTO), Intelligent Electronics Devices (IED), Communication Network, SCADA Server, SCADA/HMI System, Various SCADA Architectures ,advantages and disadvantages, Case studies in SCADA Applications	
Unit-4 - Distributed Control System and Computer Based Industrial Control	***9 Hour***
Benefits of Automatic Process control, Building blocks of Automations systems , Need of Distributed Control system, Features of DCS, Elements of DCS, DCS Configuration, Applications, Types of Interfacing Systems , Operator interfaces - Low level and high level operator interfaces – Displays interface- Human machine Interface (HMI) - Engineering interfaces – Low level and high level engineering interfaces – Factors to be considered in selecting DCS , Various Process Interfacing issues, Communication facilities , Case studies- Sugar industry , paper industry .	

Unit-5 - Modelling for Advanced Process Control and Model Based System Engineering	***9 Hour***
Need for system Modelling, Types of Plant Automation, Cement Plant, Steel Plant, Model Based system Engineering, Implementation of modern based system Engineering, approaches in MBSE, Study of Advanced Process Control, Fuzzy Logic Based Control, Neural Network based control, PID Control, Merits and demerits of Advanced process control, Case studies on Model Based System Engineering	

Learning Resources	1. *P. Groover, "Automation, Production systems and Computer Integrated Manufacturing", Pearson Education, 5th edition, 2009.* 2. *Gary Dunning,"Introduction to Programmable Logic Controllers",3rd India edition, Cengage Learning, 2007* 3. *Krishna Kant "Computer Based Process Control", Prentice Hall ofIndia, 2004.* 4. *Gerardus Blokdyk, "Distributed Control System", 5starcooks firstlatest Edition, 2020.*	5. *Jose A. Romagnoli, Ahmet Palazoglu, "Introduction to Process control", CRCTaylor and Francisgroup, 2005.* 6. *John Webb, "Programmable Logic Controllers: Principles andApplications",5th edition Prentice Hall of India, 2012* 7. *Richard Zurawski, "Industrial Communication Technology Handbook" 2ndedition, CRC Press, 2015.* 8. *Patrice Micouin, " Model Based System Engineering-Fundamentals", ISTE LtdJohn Wiley& Sons .Inc , First publication in Great Britain, 2014*

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.D.Chandrasekar, Sohar Aluminium Pvt Ltd, Gulf*	1. *Dr.J.Prakash, MIT University, Chennai*	1. *Dr.G.Murali, SRMIST*
2. *Dr.K.Karthikeyan, Hitachi Energy, Bangalore*	2. *Dr.P.Karthikeyan, MIT University, Chennai*	2. *Mr.K.Saravanan, SRMIST*

Course Code	21MHE418L	Course Name	ROBOTICS LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the fundamentals of Linear Algebra and Spatial Transformations*
CLR-2:	*understand the Manipulator Robot Kinematics Trajectory Planning and Control*
CLR-3:	*assimilate the way programs are to be created and optimised for an Industrial Robot*
CLR-4:	*learn the steps to simulate a mobile robot*
CLR-5:	*understand the fundamentals of Robot Operating 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:	*apply linear Algebra and spatial transformations concepts in real-time Robotics Challenges*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*plan and Control the trajectory of a Manipulator Robot*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*program an Industrial Robot*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	
CO-4:	*model and Simulate a Mobile Robot in a desired environment*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*implement and Visualize the operation of a Robot in Robot Operating System*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Basics of Linear Algebra and Spatial Transformations — ***15 Hour***

Vectors, matrix operations, matrix types and properties of matrices-Matrix and Array Operations-Eigen decomposition and application-Singular value decomposition-Pseudo inverse of a matrix-Solving system of linear equations-2D Rotation and Translation-Understanding Rotation Matrix-Homogeneous transformation matrix-Fixed Angles. Euler Angles, Singularities and Gimbal Lock-Unit Quaternions and conversions-Equivalent Angle-Axis Representation and conversion-Multi-dimensional and multi-segment trajectories-Interpolation of orientation in 3D-Time varying coordinate frames

Unit-2 - Manipulator Robot Kinematics Trajectory Planning and Control — ***15 Hour***

Understanding D-H parameters, 2R manipulator simulations - Forward kinematics of a 2R manipulator - SCARA robot forward kinematics - 6R spatial robot forward kinematics - Inverse Kinematics of 2R planar robot - 6R spatial robot inverse kinematics – closed form solution - 6R spatial robot inverse kinematics - numerical solution - Joint space trajectory planning - Cartesian space trajectory planning - Developing a simple walking robot - Jacobian matrix and Singularities of 2R robot - Jacobian and singularities of a 6R robot - Manipulability and workspace visualization - Understanding static forces in manipulators - Resolved rate motion control

Unit-3 - Industrial Robot Programming — ***15 Hour***

Getting started with GUI of Robot programing software - Foundations of robot programing language - Foundations of robot programing language - Programming with Flexpendant / Virtual Flex Pendant - Create, Add, Edit, Save and Run - Understanding Routines, Modules, Program Pointer and Motion Pointer - Creating a solution with station and a robot controller - Creating frames, solids, setting-up local origin - Creating work object, target, empty path - Synchronize virtual controller with Robot controller to run a basics movement program - Modelling Functions and Measuring - Action Programming - Action Programming - Smart Component Usage - Working with I/O signals

Unit-4 - Mobile Robot Simulation — ***15 Hour***

Car-like mobile robot kinematics – Moving to a point - Car-like mobile robot kinematics – Following a line, path - Car-like mobile robot kinematics – Moving to apose - Modelling of quad-copter aerial vehicle - Simulation of quad-copter aerial vehicle - Map building - LIDAR to grid map - Kalman Filter Basics - Extended Kalman Filter for Localization - Dijkstra algorithm for path planning - Dijkstra algorithm for path planning - D Lite path planning - Path tracking – Move to a Pose Control - Path tracking – Stanley Control*

Unit-5 - Robot Operating System	***15 Hour***
Installation of ROS - Workspace and Package - Exploring ROS Filesystem IDE - ROS Node creation, Publisher and Subscriber - Understanding roslaunch, rosbag Understanding ROS Topics and rqt - Understanding Services and Parameters - Understanding rcl, rclpy with Turtlesim - Implementing Topics, Service, Parameters - Visualization Tools: rviz and Gazebo - Spatial descriptions in ROS - Wandering robot - Follower Robot	

Learning Resources		
	1. *Robotics, Vision and Control: Fundamental Algorithms inMATLAB - Peter Corke, 2nd ed., Springer, 2017.* 2. *Introduction to Robotics: Mechanics and Control- John Craig, 3rd ed., Pearson, 2017* 3. *Programming Robots with ROS: A Practical Introduction to theRobot Operating System by Morgan Quigley, Brian Gerkey, et al. 12th ed., O'Reilly, 2015*	4. *Self-Driving Cars with Duckietown - Edx.org* 5. *ABB Robotics - Technical reference manual RAPID Instructions,Functions and Data types.*

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%*	-	*20%*	-	-
Level 3	*Apply*	-	*30%*	-	*25%*	-	*25%*	-	-
Level 4	*Analyze*	-	*30%*	-	*25%*	-	*25%*	-	-
Level 5	*Evaluate*	-	-	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Mohammed Sagheer, Wabco Technology Center,*	1. *Dr.R.Thiyagarajan, Indian Institute of Technology Tirupati,*	1. *Dr.R.Ranjith Pillai, SRM IST*
2. *Mr.Shankar Bharathi, L&T Technology, Chennai*	2. *Dr.P.Karthikeyan, MIT Campus, Anna University,*	2. *Mr.A.Josin Hippolitus, SRM IST*

Course Code	21MHE419T	Course Name	DIGITAL MANUFACTURING	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:	*learn about CAE, PLM and numerical control machining integration technology*
CLR-2:	*familiar in interfacing and Communication with industrial machinery*
CLR-3:	*know to formulate manufacturing computational model*
CLR-4:	*gain knowledge about intelligent controls used in various machinery environment*
CLR-5:	*know about future development in digital manufacturing*

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:	*gain knowledge in fundamentals of Digital Manufacturing*	*3*	*3*	-	*3*	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*impart Knowledge in industrial machinery*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*learn the information characteristics of manufacturing*	*3*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*understand the concept of intelligent control in digital manufacturing*	*3*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*impart future development and application of digital manufacturing*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction to Digital Manufacturing — ***9 Hour***

Introduction and Concepts of digital manufacturing – digital networked manufacturing and new generation intelligent manufacturing- Introduction to CIM - product life cycle management (PLM) - Applications of PLM - product data management (PDM) - Applications of PDM - Virtual environment for digital manufacturing - Application of virtual environment (DM) - Operation mode and architecture of digital manufacturing system.

Unit-2 - Modelling in Digital Manufacturing — ***9 Hour***

Manufacturing computational model - Modelling theory of digital manufacturing - basic concepts of computing manufacturing methodology - Application of C Space - Screw space - virtual prototyping - Basic theory and applications of virtual prototyping- Basic theory and application of Reverse Engineering – Discrete model of manufacturing computing - Discrete model of controlled process in manufacturing.

Unit-3 - Manufacturing Information System — ***9 Hour***

Information characteristics of manufacturing - Information activities - manufacturing informatics - Basic concept of measurement of manufacturing information- Mechanism of synthesizing manufacturing information - Materialization of manufacturing information - integration and block diagram model for manufacturing information – introduction , principle and mechanism of sharing manufacturing resources.

Unit-4 - Intelligent Control in Manufacturing — ***9 Hour***

Introduction to intelligent control in digital manufacturing – concept of intelligent multi information sensing - Application of sensor in processing - Intelligent multi information fusing - Elements of multi information fusing - Mechanism of tool condition monitoring - Tool condition monitoring based on fuzzy theory and neural network.

Unit-5 - Future Developments — ***9 Hour***

Future development and application of digital manufacturing - Various digital technologies in product lifecycle - Digital equipment - digital processing technology - Basic concept and application of NEMS in Digital manufacturing – micro nano-equipement systems - Extremalization of digital manufacturing – Digital manufacturing Technology in Micro Nano Manufacturing - bionic Machinery and its application of in digital manufacturing.

Learning Resources	1. *Zudezhou, Shanexie, Dejunchen, "fundamentals of digital manufacturing science". Springer, 2012.* 2. *Lihui, Wang, Andrew, Y C Nee, "Collaborative Design and Planningfor Digital Manufacturing", springer, 2009.* 3. *Saaksvuori,Antti,Anselmi,Immonen,'Product LifecycleManagement', Springer New York , 2008*	4. *Stark, J., "Product Lifecycle Management - 21st Century Paradigm forProduct Realisation", Springer, 2005.* 5. *Vukicajovanovic, Michealdebevee. "Applications of digital manufacturing in manufacturing process support" proceedings of IAJC/ISAM, 2014.*

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.K.Balaguru, Hindustan Aeronautics limited,*	1. *Dr.V. Senthilkumar , NIT Tiruchirappalli,*	1. *Mr. Arivarasan J, SRMIST*
2. *Mr.V.G. Balaji, Rotork control, India pvt limited,*	2. *Dr. C. Velmurugan, IIIT Tiruchirappalli,*	2. *Ms. D.Gayathri, SRMIST*

Course Code	21MHE420T	Course Name	ENERGY HARVESTING METHODS AND APPLICATIONS	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:	be familiar with the solar energy harvesting methods and applications
CLR-2:	understand the wind energy system and its Grid Interconnection Topologies
CLR-3:	get acquainted with ocean energy harvesting methods and their control
CLR-4:	obtain knowledge of Piezoelectric Energy Harvesting techniques and their modeling
CLR-5:	be familiar with modeling and analysis of Electromagnetic Energy Harvesting

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:	analyze and apply the concepts of solar energy harvesting techniques	3	2	1	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	analyze the electrical machines and power electronic circuits suitable for wind energy harvesting system	3	2	1	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	analyze the different methods of ocean energy harvesting and grid connection topologies	3	2	1	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	develop the model of a piezoelectric generator and analyze the material used for piezoelectric energy harvesting	3	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	develop the model of an Electromagnetic Energy Harvester	3	2	1	-	-	-	-	-	-	-	-	-	-	-	2

Unit-1 - Solar Energy Harvesting	**9 Hour**
Characteristics of Photovoltaic (PV) Systems, PV Models and Equivalent Circuits, Sun Tracking Systems, Maximum Power Point Tracking (MPPT) Techniques, Power Electronic Interfaces for PV Systems, Sizing the PV Panel and Battery Pack in a Stand-alone PV Applications, Solar Thermal collectors. Solar Energy Applications: Residential, Electric Vehicle, Naval, and Space	
Unit-2 - Wind Energy Harvesting	**9 Hour**
Fundamentals of Wind Energy, Wind Turbines and Different Electrical Machines in Wind Turbines, Power Electronic Interfaces, and Grid Interconnection Topologies.	
Unit-3 - Ocean Energy Harvesting	**9 Hour**
Physical Principles of Tidal Energy, Tidal Turbines (Horizontal axis turbines and Vertical Axis Turbines) and grid connected systems, Principles of Energy available from Ocean Waves, Off-shore and Near-shore Wave Energy Harvesting, Wave Power Absorbers, Wave power turbines, and grid connection topologies, Ocean Thermal Energy, Thermodynamic energy conversion principles, Closed-cycle and open-cycle OTEC Systems, Components of OTEC Systems, Control of OTEC Power Plants, and Multipurpose Utilization of OTEC Systems	
Unit-4 - Piezoelectric Energy Harvesting	**9 Hour**
Physics and Characteristics of Piezoelectric Effects, Materials, and Mathematical Description of Piezoelectricity Effect, Piezoelectric Parameters, Modeling of Piezoelectric Generators, 2 DOF piezoelectric energy harvester, Power Electronic Interfaces for Piezoelectric Energy Harvesting, Piezoelectric Energy Harvesting Applications.	
Unit-5 - Electromagnetic Energy Harvesting	**9 Hour**
Linear Generators, Physics, Mathematical Models, and Structures, 2 & 3 DOF electromagnetic energy harvester, Hybrid Piezoelectric-Electromagnetic Energy Harvesting, Recent Applications on Electromagnetic Energy Harvesting.	

Learning Resources	1. *Alireza Khaligh, Omer C. Onar," Energy Harvesting, Solar, Wind,and Ocean Energy Conversion Systems", Taylor & Francis, 2017.* 2. *K. Bogus. "Solar Electricity", Wiley,2000.*	3. *Sajid Rafique , "Piezoelectric Vibration Energy Harvesting Modeling &Experiments", Springer International Publishing, 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. *Mr.Senthil Kumar S, Grundfos pumps India Pvt Ltd*	1. *Dr M.Bhaskaran, KSR college of Technology, Thiruchengode*	1. *Dr.R.Gangadevi, SRMIST*
2. *Mrs.Krithika, Grundfos Pumps India pvt ltd*	2. *Dr.P.Ravichandran, Kongu Engineering College, Erode*	2. *Dr.M.Santhosh Rani, SRMIST*

Course Code	21MHE421T	Course Name	ERGONOMIC DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basics of Ergonomic Design*
CLR-2:	*comprehend the fundamentals of Anthropometry*
CLR-3:	*acquire the knowledge of Human Comfort*
CLR-4:	*understand the Ergonomic Design principles*
CLR-5:	*apprehend the basics of Virtual Ergonomics*

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 basics of Ergonomics*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*understand the fundamentals of Anthropometry*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*assess human comfort value*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*design ergonomically for any task*	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*understand the basics of Virtual Ergonomics*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Ergonomics ***9 Hour***

Introduction to Ergonomics, Human Factors and Ergonomics. Brief History of Ergonomics. Application of Ergonomics. Ergonomics design methodology. Design process involving ergonomics check. Effectiveness and Cost-Effectiveness of Ergonomics. Man-Machine-Environment interaction system. Horizontaland vertical work surface. Principles of Universal Design. A design perspective – human compatibility, comfort and adaptability.

Unit-2 - Anthropometry ***9 Hour***

Introduction to Anthropometry, Myth of the Average Human. Human body structure basics of muscles, bones and joints, and their working principles. Anthropometric Measurements and standards associated. Structural and Functional Anthropometry. Statistical treatment (Distribution and Diversity). 2D/3D anthropometry measurement and its principles.

Unit-3 - Human Comfort ***9 Hour***

Occupational Safety and Health Aspects. Work Related Musculoskeletal disorders. Types of WMSDs. Interface Pressure Measurement. Whole Body Vibration. SEAT value. Hand Arm Vibration. Thermal comfort. Muscle Comfort. Cognitive aspects of user-system interaction. Comfort measuring instruments. Uncertainty and Calibration.

Unit-4 - Ergonomic Design and Analysis ***9 Hour***

Ergonomic Design of workstation and Work Task. Permissible Loads for Manual Material Handling. Rapid Upper Limb Assessment (RULA) Ergonomic Analysis. Limits for Lifting and Lowing. Lifting and Lowering Ergonomic Analysis. Ergonomic Rules for Industrial Manual Handling Tasks. NIOSH 1981, NIOSH 1991 and Snook/Ciriello Guidelines. Pushing and Pulling Ergonomic Analysis and Carrying Analysis. Spinal Loads.

Unit-5 - Virtual Ergonomics ***9 Hour***

Virtual Ergonomics and its advantages. Digital Human Modeling and Simulation. Techniques of virtual ergonomics evaluation using DHMs. Application of digital human modeling and simulation in various industrial sectors. Automotive Ergonomics – control, display, visibility, entry and exit by drivers and passenger

Learning Resources	1. *R S Bridger , "Introduction to Ergonomics", , Routledge Taylor &Francis Group* 2. *E.N. Corlett and T.S. Clark, "The Ergonomics of workspaces and Machines – A Design Manual," , Taylor and Francis* 3. *Pamela McCauley Bush, "Ergonomics Foundation Principles, Applications, and Technologies," , CRC Press*	4. *Editor: Gavriel Salvend,Y "Handbook of Human factors andErgonomics", John Wiley & Sons INC 2012* 5. *Mark Lehto, Steven J landry, "Introduction to Human factors and Ergonomics for Engineers", CRC Press, Taylor & FrancisGroup*

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.Sureshkumar S,Global virtual Process Engineering, Ford Global Technology & Business centre, Chennai. Email:ssures19@ford.com*	1. *Prof.Seung Nam Min, School of Smart Safety Systems, Dongyan University, South Korea, email:msnijn12@dyu.ac.kr*	1. *Dr.G.Murali, , SRMIST*
2. *Mr.Chandrasekar.N.,Global virtual Process Engineering, Ford Global Technology & Business centre, Chennai. Email:nchand16@ford.com*	2. *Prof. Kyung-Sun Lee, Division of Energy resources Engineering and Industrial Engineering, Kangwon National University, South Korea, email:ksunjee@kangwon.ac.kr*	2. *Dr.S.Murali, SRMIST*

Course Code	21MHE422T	Course Name	INDUSTRIAL DATA COMMUNICATION	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:	*provide fundamental knowledge of communication protocols*
CLR-2:	*present the different wireless technologies based on applications*
CLR-3:	*provide industrial applications of foundation fieldbus communication*
CLR-4:	*introduce different types of networks in industrial applications*
CLR-5:	*provide the various protocols for industrial applications*

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 basic communication protocols*	2	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*explain different wireless technologies used in industrial applications*	3	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*differentiate different types of networks at various levels of communication*	3	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*apply Foundation Fieldbus communication for industry applications*	3	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*explain the various communication protocols for industrial applications*	3	-	-	-	-	-	-	-		-	-	-	-	-	*1*

Unit-1 - Introduction to Networks — ***9 Hour***

OSI reference model, Protocols, overview -RS 232, RS485, AS-interface, CAN, LIN, Devicenet- applications

Unit-2 - Wireless Technologies — ***9 Hour***

Satellite systems, Wireless LANs , WiFi, VPAN, IEEE 802.15.4-Zigbee, Bluetooth GPRS and – their comparison, limitations and characteristics, Introduction to IOT and IIOT, HF RFID ,– their relevance to industrial applications

Unit-3 - Industrial Networks & HART — ***9 Hour***

Industrial Network Requirements – Process Automation Controllers – Programmable Logic Controllers –PROFIBUS/PROFINET, HART:-Architecture, Physical, Data Link, Application, Communication Technique, Normal and burst mode of communication, Troubleshooting, Benefits of HART

Unit-4 - Field Buses — ***9 Hour***

Foundation Fieldbus:- Fieldbus requirement, features, advantages, fieldbus components, types, architecture-physical, data link, application layer, system and network management, wiring, segment functionality checking, installation in safe and hazardous area and troubleshooting, function block application process.

Unit-5 - Advanced Protocols in Industry — ***9 Hour***

Interaction Protocols for Multi-Robot Systems - Queue Telemetry Transport (MQTT), Constrained Application Protocol (CoAP) – Industry 4.0- EtherCAT - ,OPC UA , Ethernet TSN - Automotive industry- FlexRay and MOST Automotive Protocols - 6G communication protocol – Defense communication protocol

Learning Resources	1. *Deon Reynders,Steve Mackay,Edwin Wright, : Practical Industrial Data Communications ,1st edition ELSEVEIR,2005.* 2. *Lawrence M Thompson, : Industrial Data Communication, 2nd edition , 1997* 3. *Bowden,R., "HART Application Guide", HART Communication Foundation, 1999.*	4. *Bela G.Liptak, "Instrument Engineers" Handbook, Volume 3: Process Software and Digital Networks", 4th Edition, CRC Press, 2011.* 5. *Berge,J., "Field Buses for Process Control: Engineering, Operation, and Maintenance", ISA Press, 2004.* 6. *Buchanan,W., "Computer Busses: Design and Application", CRC Press, 2000.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*60%*	*-*	*20%*	*-*	*40%*	*-*
Level 2	*Understand*	*40%*	*-*	*40%*	*-*	*40%*	*-*
Level 3	*Apply*	*0%*	*-*	*40%*	*-*	*20%*	*-*
Level 4	*Analyze*	*60%*	*-*	*20%*	*-*	*40%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21MHE423T	Course Name	DIGITAL SIGNAL PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MHC301T*	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:	*apply digital conversion techniques on signals and system*
CLR-2:	*analyze discrete systems using transforms*
CLR-3:	*implement different structures for IIR and FIR filters*
CLR-4:	*design IIR and FIR filter techniques using approximations*
CLR-5:	*demonstrate the DSP processor for signal processing applications*

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:	*express systems in discrete form*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*analyze discrete systems and signals using transforms*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*construct the structures for IIR and FIR filters*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*design a IIR and FIR filtering structures for the required specifications*	*3*	*2*	*1*	-	*2*	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*implement digital filters using DSP processor*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Introduction to Digital Signal Processing	***9 Hour***
Discrete system and its properties, LSI system-Characterization of LSI system using it's impulse response, Convolution, Convolution Properties, Sampling Techniques, Review of Sampling Theorem, and Reconstruction, Nyquist rate, Aliasing effect, Quantization-Quantization error.	
Unit-2 - Discrete Time Systems	***9 Hour***
Z-transform and its properties, inverse z-transforms; difference equation – Solution by Z-transform, application to discrete systems – Stability analysis, frequency response- DTFT and Properties of DTFT, DFT, Properties of DFT – Circular Convolution – Filtering methods based on DFT-Introduction to FFT	
Unit-3 - IIR Filter Design	***9 Hour***
Structures of IIR – Analog filter design – Discrete time IIR filter from analog filter – IIR filter design by Impulse Invariance, Bilinear transformation, Approximation of derivatives – (LPF, HPF, BPF, BRF) filter design using frequency translation., IIR filter design using Butterworth and Chebyshev approximations	
Unit-4 - FIR Filter Design	***9 Hour***
Structures of FIR – Linear phase FIR filter – Fourier Series – Filter design using windowing techniques (Rectangular Window, Hamming Window, Hanning Window), Frequency sampling techniques – Finite word length effects in digital Filters: Errors, Limit Cycle, Noise Power Spectrum.	
Unit-5 - Digital Signal Processor and Case Study	***9 Hour***
Introduction – Architecture – Features – Addressing Formats – Functional modes – Introduction to Commercial DS Processors. Case studies of digital filtering techniques to remove sensor noise	

Learning Resources	1. *Alan V. Oppenheim, Ronald W. Schafer – "Discrete Time Signal Processing", Prentice Hall of India (Private) Limited, New Delhi, 1994 (c1989).* 2. *John G. Proakis, Dimitris G. Manolakis – "Digital Signal Processing – Principles, Algorithms and Applications", Third Edition, Prentice Hall of India Private Limited, New Delhi – 110 001, 1997.* 3. *Sanjit K. Mitra, "Digital Signal Processing – A computer-based approach", Mc Graw Hill International Edition, Second Edition, 2001*	4. *Sanjit K. Mitra, "Digital Signal Processing Laboratory using MATLAB", Mc Graw Hill International Edition, 2000.* 5. *James H. McClellan, Ronald W. Schafer, Mark A. Yoder, "DSP First: A Multimedia Approach", Prentice Hall, NJ, (c 1998 by Prentice Hall).*

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. T. Balakumaram, Assistant Professor, Department of ECE, Coimbatore Institute of Technology, Coimbatore*	1. *Dr. M. Mohamed Rabik, 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.*	2. *Dr. S. Vani, SRMIST*
		3. *Dr. Vimala Starbino, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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