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 – 18E
(Syllabi for Mechatronics Engineering (Industrial IoT and Systems 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

ACADEMIC CURRICULA

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	21MHE465T	Course Name	INTRODUCTION TO IoT AND IIoT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire fundamental knowledge in IoT and IIoT.*
CLR-2:	*explore the various actuators and sensors used in IoT applications.*
CLR-3:	*acquire a basic understanding of IoT networks and popular communication protocols.*
CLR-4:	*acquire fundamentals of network layer, security, and cloud computing platforms.*
CLR-5:	*explore the various use cases and applications of Industrial IoT.*

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 basic architecture and elements of IIoT.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*describe the various sensors and actuators used in the IoT application.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*describe the various communication technologies and their selection criteria based on the application.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*explain the network layer and basics of data management in IoT systems*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*explain the application and use cases of IoT in various domains.*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Fundamentals of IoT and IIoT	***8 Hours***
History and evolution – basic framework, Architecture and elements of IoT – Sensor technologies – Connectivity and networking – data storage and processing in IoT- key difference between IoT and IIoT – Specific examples for IoT and IIoT (specific to industrial environments)	
Unit-2: Actuators and Sensors in IoT	***9 Hours***
Basic sensors used in IoT (any case study- home automation, medical and industrial automation) - basic actuators used in IoT (any case study- home automation, medical and industrial automation) - Concept of Smart sensors - Data acquisition and methods - Sensor calibration - Data sampling and importance of processing - actuator and sensor integration in IoT.	
Unit-3: IoT Networks and Communication Protocols	***10 Hours***
Introduction to types and features of Wireless communication technologies – Types of IoT networks: low power, short range networks (Bluetooth, Wi-Fi, Zigbee) , low power, wide area networks (4G LTE IoT, 5G IoT, LoRaWAN) – Introduction to IoT protocols – Application Layer : Advanced Message Queuing Protocol (AMQP) , Constrained Application Protocol (CoAP), Data Distribution Service (DDS), Message Queue Telemetry Transport (MQTT) – Transport layer : Transmission Control Protocol (TCP) , User Datagram Protocol (UDP)	
Unit-4: Connectivity and Data Management	***9 Hours***
Network Layer: IP (IPv4 and IPv6) - Data link Layer (IEEE 802.15.4 , LPWAN) – Physical layer (BLE, Ethernet, LTE, RFID, Wi-Fi, Zigbee) – IoT Gateway – Cloud computing platforms – IoT security- IoT data management, processing and analytics.	

Unit-5: Application and use Cases of Industrial IoT	***9 Hours***
Health care – predictive maintenance – Virtual Reality and IoT – Digital twins and IoT – Manufacturing Industries	

Learning Resources	1. *Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.* 2. *Arsheep Bahga , Vijay Madisetti , " INTERNET OF THINGS - A HANDS-ON APPROACH", Orient Blackswan Private Limited - New Delhi; First Edition, 2015* 3. *Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw Hill Education; First Edition, March 2017*	4. *https://azure.microsoft.com/en-in/solutions/iot/iot-technology-protocols* 5. *Hiroto Yasuura, Chong-Min Kyung , Yongpan Liu , Youn-Long Lin ,"Smart Sensors at the IoT Frontier, Springer; 1st ed. 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%*	-	*10%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
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. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	*1.Dr. R. Ranjith Pillai, SRMIST*
2. Mr. Ganesh Ram, Tunga Systems	*2.Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2.Dr. S Vasanth, SRMIST*

Course Code	21MHE466T	Course Name	FOUNDATIONS OF DIGITAL AND SMART MANUFACTURING TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explore the various applications, architectures, and popular communication protocols used in IIoT.*
CLR-2:	*acquire knowledge in the domain of data management and processing in IoT.*
CLR-3:	*explore the concept of digital twin technology*
CLR-4:	*acquire knowledge in the building block of cyber-physical systems*
CLR-5:	*explore the various manufacturing techniques and automation process*

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 various applications and architectures of IIoT.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*apply the knowledge of AI and data analysis in the IIoT domain.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*familiarize with the concepts of Digital Twin Technology.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*explain the fundamental elements and integration of Cyber-Physical Systems.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*describe the various manufacturing techniques and processes used in the I4.0.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Industrial Internet of Things (IIoT) in Manufacturing	***10 Hours***
Introduction to IIoT and its role in digital manufacturing - IIoT architectures and layers – Popular communication protocols - IIoT applications in various manufacturing domains (case study)- Industrial Ethernet Networks, types of Ethernet networks (e.g. PROFINET, EtherNet/IP, Modbus TCP), Ethernet network design and implementation considerations, Ethernet network communication protocols and standards (e.g. TCP/IP, UDP, Ethernet/IP) - IIoT Data Communications, protocols (e.g. OPC UA, MQTT, CoAP), Data transfer methods (e.g. Request/Response, Publish/Subscribe), Security considerations in IIoT data communications	
Unit-2: Data Analytics and Artificial Intelligence in Manufacturing	***9 Hours***
Data collection and management - data collection methods used in IIoT, including sensors, gateways, and other devices - storage and managing large amounts of data - Data preprocessing, managing missing data, outliers, and other anomalies (Use of AI tools) - Descriptive analytics, summarizing and visualizing data, including statistical methods, charts, and graphs – Predictive analytics: regression analysis, time-series analysis, and machine learning algorithms - Prescriptive analytics : optimization algorithms and decision trees.	
Unit-3: Digital Twin Technology	***9 Hours***
Concept and principles of digital twin in manufacturing, Digital twin development- software tools used - integration with physical systems- case study	
Unit-4: Introduction to Cyber-Physical Systems (CPS)	***9 Hours***
Definition of CPS - Physical components- sensors and actuators, Computational and Communication Elements, Integration and Control- Data Acquisition, Data Analysis, network and security	

Unit-5: Manufacturing Techniques and Automation	***9 Hours***
Robotics and Automation in Manufacturing, Additive Manufacturing and 3D Printing, Manufacturing Process Optimization	

Learning Resources	1. *Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.* 2. *Weidong Li , Yuchen Liang , Sheng Wang, " Data Driven Smart Manufacturing Technologies and Applications", Springer; 1st ed. 2021* 3. *Rajeev Alur, "Principles of Cyber-Physical Systems" , MIT Press; 2015*	4. *Anand Nayyar and Akshi Kumar, "A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development", Springer, 2020.* 5. *https://azure.microsoft.com/en-in/solutions/iot/iot-technology-protocols* 6. *Aboul Ella Hassanien , Ashraf Darwish , Vaclav Snasel, "Digital Twins for Digital Transformation: Innovation in Industry", Springer ,2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*10%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
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. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	1. *Dr. G. Murali, SRMIST*
2. Mr. Ganesh Ram, Tunga Systems	*2.Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	2. *Dr. R. Ranjith Pillai, SRMIST*

Course Code	21MHE467J	Course Name	SENSORS AND ACTUATORS FOR IoT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*explore the sensors, actuators, and their integration in IoT.*
CLR-2:	*acquire knowledge in the field of sensors used in IoT and its technical interpretation.*
CLR-3:	*acquire knowledge in the field of actuators used in IoT and their integration into IoT systems.*
CLR-4:	*analyze the method of data acquisition and signal conditioning.*
CLR-5:	*explore various applications of sensor and actuator integration in IoT.*

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 role of sensors and actuators in IoT.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*describe various sensors used in IoT and their specifications.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*describe various actuators used in IoT and their specifications.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*apply the concept of data acquisition and data processing in IoT.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*familiarize with the application and use cases of sensor and actuator integration in IoT.*	*3*	-	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Introduction to Sensors and Actuators in IoT ***12 Hours***

Role of sensors and actuators in IoT application - Characteristics of a smart sensor – Selection of sensor and its important industrial interfaces – applications of actuators in IoT – Sensor and actuator integration for IoT

Exp 1: Study on specifications of smart sensor Exp 2:
Study of sensor interfaces

Unit-2: Sensor technologies and types for IoT ***12 Hours***

Sensor selection, Characteristics, and datasheet interpretation – Calibration and pre-processing – Types of sensors popular for a specific application (industrial process, healthcare, home automation, vehicle safety and networking, biomedical, etc.): environmental – (humidity, temperature, light, gas etc.), proximity, motion, position, biometric, IMU, used in Biomedical applications, wearable sensors.
Exp 3: Sensor interface and calibration
Exp 4: Real time sensor data acquisition and transmission.

Unit-3: Actuator Technologies and Application ***12 Hours***

Types of actuators- motor, relays, valves - selection criteria - Integration of actuator with IoT systems – control of actuators - application: robotics & automation, smart doors, smart lighting, etc.
Exp 5: Actuator drive and control.
Exp 6: Sensor actuator integration and control.

Unit-4: Sensor data acquisition and processing	***12 Hours***
Acquisition methods – Acquisition hardware and selection criteria- consideration to acquire series of data from multiple sensors -pre-processing - signal conditioning and filtering – concept of fusion algorithms- example of data acquisition (for multiple sensors) with hardware with real-time application. Exp 7: Sensor processing and visualization in IoT dashboard. Exp 8: Data analytics and decision-making .	
Unit-5: Case Study and Practical Application	***12 Hours***
Home automation: Smart lighting systems – Automotive management systems: Power train sensor, chassis management, vehicle convenience and security systems – Wearable sensors Exp 9: Home automation. Exp 10: Factory automation .	

Learning Resources	1. *Jacob Fraden, "Handbook of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.* 2. *Maurizio Di Paolo Emilio, "Data Acquisition Systems- Fundamentals to Applied Design" , Springer, 2013.* 3. *Data Acquisition Toolbox – User's Guide, MathWorks, 2016*	4. *Holger Karl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks" 2011, 1st ed., John Wiley & Sons, New Jersey.* 5. *Edward Sazonov, Michael R. Newman, "Wearable Sensors: Fundamentals, Implementation and Applications", 2014, 1st Edition, Academic Press, Cambridge.* 6. *Prof. Satish Jain ,Shashi Singh , "Internet of Things and its Applications: Made simple, BPB Publications; 1st edition ,2020.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2- Practice (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd	*1.Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	*1. Dr. R. Ranjith Pillai, SRMIST*
2. Mr. Ganesh Ram, Tunga Systems	*2. Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2. Dr. S Vasanth, SRMIST*

Course Code	21MHE468T	Course Name	COMMUNICATION NETWORKS IN IoT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge of various wireless technologies used in IoT.*
CLR-2:	*explore the IoT networks and common protocols.*
CLR-3:	*explore the IoT network architecture and the role of IoT gateway.*
CLR-4:	*familiarize with the concept of data management in IoT.*
CLR-5:	*explore the concept of cloud computing and open-source platforms.*

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 various wireless communications techniques used in IoT.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*describe the popular IoT communication protocols.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	--	*3*
CO-3:	*familiarize the IoT network architecture and the concept of IoT gateways.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*explain the concept of data management.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*familiarize the concept of cloud computing and platforms.*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Wireless Communication Technologies in IoT	***8 Hours***
Review of computer communication concepts (OSI layers, components, packet communication, Networks, TCP-IP, subnetting, IPV4 addressing, and challenges). IPV6 addressing - Selection of Wireless technologies: BLE, Ethernet, LTE, RFID, Zigbee, NFC.	
Unit-2: IoT-Specific Communication Protocols	***10 Hours***
IoT protocol architecture – IoT networks: low power, short-range networks and Low power, wide area networks – Application layer – transport layer – network layer – Data link layer – Physical layer – IoT protocols: MQTT, UDP, MQTT brokers - publish-subscribe modes, HTTP, COAP, AMQP and gateway protocols	
Unit-3: IoT Network Architecture, IoT Addressing and Security	***9 Hours***
Edge computing and fog computing for distributed IoT networks - Hierarchical network architectures for IoT deployments - Peer-to-peer (P2P) and mesh networking in IoT environments - IoT gateways and their role in network integration, IPv6 and IoT Addressing, OPC UA architecture.	
Unit-4: Network Protocols for IoT Data Management	***9 Hours***
Time-sensitive networking (TSN) for real-time IoT data transmission - data synchronization and consistency in distributed systems - quality of service considerations	
Unit-5: Cloud Computing and IoT- Case Study and Practical Applications	***9 Hours***
Cloud platforms (open source) and services for IoT data storage and processing, Integration of IoT devices with cloud infrastructure, Cloud-based analytics and decision-making in IoT applications – Cloud dashboards.	

Learning Resources	1. *Industrial Wireless Sensor Networks: Applications, Protocols, and Standards (Industrial Electronics), Gerhard P. Hancke, V. Cagri Gungoer, CRC Press Inc, 1st edition, 2013* 2. *Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks", 2011, 1st ed., John Wiley & Sons, New Jersey.* 3. *Cloud Computing, Mehul Mahrishi Kamal Kant Hiran, Ruchi Doshi, Dr. Fagbola Temitayo, BPB, Publications; 1st edition, 2019*	4. *Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: "Private Communication in a public World", PTR Prentice Hall, Second Edition, 2002.* 5. *https://azure.microsoft.com/en-in/solutions/iot/iot-technology-protocols*

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%*	-	*10%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Guna Surendra, Hitachi, Japan	1. *Dr. G Nagamanikandan, IIIT Hyderabad*	1. *Dr. R. Ranjith Pillai, SRMIST*
2. Mr. Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd	2. *Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2. Ms. M. Nandhini, SRMIST*

Course Code	21MHE469J	Course Name	CYBER PHYSICAL SYSTEM DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*acquire knowledge in the domain of Cyber-Physical Systems and their basic elements.*
CLR-2:	*explore the modeling and control techniques used in the design of CPS.*
CLR-3:	*explore the techniques and methods to implement the CPS for real application.*
CLR-4:	*acquire knowledge of the software tools and security aspects in the implementation of CPS*
CLR-5:	*explore the various examples of CPS through case study.*

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 elements and system-level understanding of CPS.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*apply the modeling techniques and the control in CPS.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*familiarize the tools and methods in the implementation of CPS.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*familiarize the software tools and security in the implementation of CPS.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*describe the case study of CPS.*	*3*	-	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Introduction to CPS ***12 Hour***

CPS: Motivational examples and compute platforms - Key design drivers and quality attributes of CPS - Overview of integrating physical components with computing and communication systems - physical systems (sensors and actuators) - Real-time sensing and communication for CPS - Real-time task scheduling for CPS- Examples of CPS applications in various domains such as smart grids, autonomous vehicles, and healthcare

Exp 1: Study on the key elements of CPS

Exp 2: Study of various sensor interfaces and actuator integration in CPS

Unit-2: Modelling, Simulation, and Control of CPS ***12 Hour***

Modeling techniques: Continuous systems modeling - Discrete time system modeling - Finite state machine - event modeling - Extended state machines - Hybrid system modeling - simulation tools - exercise on simulation – Analysis and Verification - Control of CPS- Examples for feedback control design, with logic specifications, Event-triggered control, Distributed control.

Exp 3: Mathematical modeling of CPS system -1

Exp 4: Physical modeling and control of CPS – 2

Unit-3: Design and implementation ***12 Hour***

Sensor and actuators interfacing and acquisition - data processing and filtering - network and interfaces - Embedded processors – Communication Protocols - Input/output interface – multitasking - task scheduling - time synchronization.

Exp 5: Sensor interface, data processing, and data registration.

Exp 6: Sensor- Actuator control integration – Specific application-based

Unit-4: Software, middleware platforms and Security in CPS	***12 Hours***
Introduction to various software tools for CPS design - Secure Deployment of CPS: Attack models, Secure task mapping and Partitioning, State estimation for attack detection – Security in Industrial control systems – Model-based method to detect attack on sensors - Review of graph theory-based models for security characterization and their limitations - Case study: Automotive hacking and smart grids *Exp 7: Study of software tools in CPS for various system-level integration* *Exp 8 : Study of security aspects and their considerations in CPS.*	
Unit-5: Case study on CPS	***12 Hours***
CPS case studies and tutorial, Automotive: ABS, Lane departure warning systems, Suspension control - Healthcare: Artificial Pancreas/Infusion Pump/Pacemaker, Green Buildings: automated lighting, AC control. *Exp 9: System level implementation – Home automation* *Exp 10: System level implementation -Factory automation.*	

Learning Resources	1. *"Embedded Systems Foundations of Cyber-Physical Systems", Peter Marwedel, Springer* 2. *Principles of Cyber-Physical Systems", Rajeev Alur, MIT Press*	3. *F. Pasqualetti, F. Dörfler and F. Bullo, "Attack Detection and Identification in Cyber Physical Systems," in IEEE Transactions on Automatic Control, vol. 58, no. 11, pp. 2715-2729, Nov. 2013.* 4. *F. Pasqualetti, F. Dörfler and F. Bullo "Control Theoretic methods for Cyber Physical Security", in IEEE Control System Magazine, pp. 110-127, Feb. 2015*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd	*1.Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	*1. Dr. R. Ranjith Pillai, SRMIST*
2. Mr. Ganesh Ram, Tunga Systems	*2. Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2. Dr. S Vasanth, SRMIST*

Course Code	21MHE470T	Course Name	CLOUD COMPUTING, BIG DATA ANALYTICS AND SECURITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain an understanding of the contemporary landscape of IT infrastructure and services.*
CLR-2:	*offer a comprehensive study of cloud computing covering diverse technologies &platforms*
CLR-3:	*familiarize the fundamentals of big data analytics, including data preprocessing, storage technologies, and batch vs. real-time processing.*
CLR-4:	*emphasize advanced topics in big data analytics, including data mining, machine learning, and their applications in natural language processing and social media analysis.*
CLR-5:	*explore essential security components in both cloud computing and big data environments.*

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 and design cloud solutions, considering service and deployment models, addressing security, scalability, and virtualization.*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*empower with cloud computing for effective cloud-based solution design and management.*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*familiarize in big data and analytics for effective large dataset analysis and insights.*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*equip with advanced skills in big data analytics, enabling effective application of machine learning and analysis in real-world contexts.*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*implement robust security measures in cloud and big data environments for data protection and threat mitigation in modern IT landscapes.*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 : Introduction to Cloud Computing and Virtualization ***8 hours***

Cloud computing concepts and Architecture-Cloud Service models (SaaS, PaaS, IaaS)-Cloud deployment Models (Public, Private, Hybrid)-Cloud Security and Privacy Considerations-Virtual Machines and Hypervisors-Containerization (Docker, Kubernetes)-Cloud Storage and Networking-Scalability and Elasticity in Cloud Environments)

Unit-2 : Cloud Computing Technologies and Platforms ***10 hours***

Cloud Storage Technologies: Object Storage, Block Storage and Content Delivery Networks (CDNs)- Cloud Computing Platforms: AWS, Microsoft Azure, Google Cloud Platform, and IBM Cloud-Serverless Computing: Function as a Service (FaaS) and Microservices Architecture4daw-Cloud Application Development: DevOps, Containers, and Continuous Integration/Continuous Deployment (CI/CD)-Cloud Orchestration and Management: Kubernetes, OpenStack, and CloudStack)

Unit-3: Big Data Fundamentals and Data Analytics ***9 hours***

Introduction to Big Data Analytics: Definition, Characteristics and Data Sources-Data Preprocessing: Data Cleaning, Transformation and Integration-Big Data Storage Technologies: Hadoop Distributed File System (HDFS)-NoSQL Databases- Batch Processing vs. Real-time Stream Processing-Big Data Visualization and Tools: Tableau, Power BI, and Apache Superset:

Unit-4 : Big Data Analytics Techniques and Tools ***9 hours***

Introduction to Data Mining and Machine Learning-Supervised Learning: Classification and Regression-Unsupervised Learning: Clustering and Dimensionality Reduction-Big Data Analytics for Natural Language Processing (NLP)-Big Data Analytics for Social Media Data and Graph Analysis
Unit-5: Security in Cloud Computing and Big Data ***9 hours***
Cloud Security: Data Encryption, Access Control, and Identity Management-Securing Cloud Applications and APIs: OAuth, OpenID Connect, and JWT-Big Data Security: Privacy-Preserving Techniques and Anonymization-Threat Detection and Incident Response in Cloud and Big Data Environments-Compliance, Governance, and Legal Issues in Cloud Computing and Big Data

Learning Resources	1. *John W. Rittinghouse, James F. Ransome, "Cloud Computing Implementation, Management and Security", CRC Press, 2010.* 2. *Syed Thouheed Ahmed, Syed Muzamil Basha, Sajeev Ram Arumugam, Kiran Kumar Patil, "Big Data Analytics & Cloud Computing", Milestone Research Publications, 2021.*	3. *Mostapha Zbakh, Mohammed Essaaidi, Pierre Manneback.Chunming Rong, "Cloud Computing and Big Data: Technologies, Applications and Security", Springer, 2019.* 4. *Renu Yadav, "Big Data Analytics tools and technologies used in cloud environment",IJCRT,2022.*

Learning Assessment

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

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms. R. J. Swathy, Lead Consultant, HCLTech	*1. Dr. Tamilarasi K, Assistant Professor, VIT*	*1. Ms. M. Nandhini, SRMIST*
2. Mr. K. Suresh, Software Engineer, Accenture	*2. Dr. G Nagamanikandan, IIIT Hyderabad*	*2. Dr. Ranjith Pillai R, SRMIST*

Course Code	21MHE471J	Course Name	X- REALITY FOR INDUSTRY 4.0	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Gain knowledge on Immersive Technologies*
CLR-2:	*Familiarize the fundamentals of Virtual Reality*
CLR-3:	*Familiarize the fundamentals of Augmented and Mixed Reality*
CLR-4:	*Explore the various applications of X Reality in I4.0*
CLR-5:	*Explore the various applications of X Reality in smart factories*

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 with the Immersive Technology*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*Describe the fundamentals of Virtual Reality*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*Describe the fundamentals of Augmented and Mixed Reality*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*Learn the applications of X Reality in general*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*Learn the applications of X Reality in smart factories*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 : Foundations of Immersive Technologies	***12 Hour***
History of Immersive technologies, Evolution and definitions, key concepts, General pipeline in XR, ideas of experience, Motivation, The Reality–Virtuality continuum, Examples for each category, VR AR/VR characteristics, start of the art in VR/AR/MR technologies, start of the art in VR/AR/MR technologies, Overview of the graphics pipeline	
Unit-2 : Virtual Reality	***12 Hour***
Stereo rendering, pose tracking : types and principles, navigation and controllers, VR Interfaces, VR Workflows, specifications of VR HMDs	
Unit-3: Augmented and Mixed Reality	***12 Hour***
AR types, devices and techniques, specifications of AR devices, Holograms, Calibration, Object Recognition, Object tracking, Spatial mapping, scene understanding.	
Unit-4 : Nature of Applications of X-Reality	***12 Hour***
XR ecosystem: hardware and software components, XR for assembly and maintenance tasks, Quality control and inspection using AR, Remote assistance and expert guidance in MR, XR in technical training and skill development, Virtual prototyping in automotive engineering	
Unit-5: Applications of X-Reality in Smart Factories	***12 Hour***
Integrating Design and Manufacturing, Training Shop floor Workers, Supporting complex Assembly Operations, Service and Maintenance, Supporting complex Sales solutions, Executive Oversight and Data Visualisation, Industry 5.0, Future prospectus	

Learning Resources	1. *John W. Rittinghouse, James F. Ransome, "Cloud Computing Implementation, Management and Security", CRC Press, 2010.* 2. *Syed Thouheed Ahmed, Syed Muzamil Basha, Sajeev Ram Arumugam, Kiran Kumar Patil, "Big Data Analytics & Cloud Computing", Milestone Research Publications, 2021.*	3. *Mostapha Zbakh, Mohammed Essaaidi, Pierre Manneback.Chunming Rong, "Cloud Computing and Big Data: Technologies, Applications and Security", Springer, 2019.* 4. *Renu Yadav, "Big Data Analytics tools and technologies used in cloud environment",IJCRT,2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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. Sathyanarayanan, NIOT	*1. Dr. P V Manivannan, IITM*	*1. Dr. R Senthilnathan, SRMIST*
2. Mr. Jai Naresh , HP	*2. Dr. P Karthikeyan, MIT Campus, Anna University*	*2. Dr. Ranjith Pillai R, SRMIST*

Course Code	21MHE472J	Course Name	AI AND ROBOTICS IN SMART FACTORIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*get exposed to the role of artificial intelligence and robotics in smart factories.*
CLR-2:	*analyze the technical requirements of various types of robots for smart factories.*
CLR-3:	*explore the applications of artificial intelligence techniques in smart factories.*
CLR-4:	*acquire knowledge of automation techniques and optimization strategies driven by AI in smart factories.*
CLR-5:	*realize the features of integrating artificial intelligence with IIoT systems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*articulate the role of artificial intelligence and robotics in smart factories.*	-	3	-	-	1	-	-	-	-	-	-	-	-	-	2
CO-2:	*describe the technical considerations of various types of robots used in smart factories.*	-	3	-	-	1	-	-	-	-	-	-	-	-	-	2
CO-3:	*apply artificial intelligence algorithms to tasks relevant to smart factories.*	-	-	3	-	1	-	-	-	-	-	-	-	-	-	2
CO-4:	*implement AI-enabled automation techniques and optimization strategies in smart factories.*	-	-	3	-	1	-	-	-	-	-	-	-	-	-	2
CO-5:	*explain the features of integrating artificial intelligence with IIoT systems.*	-	3	-	-	1	-	-	-	-	-	-	-	-	-	2

Unit-1: Introduction to AI & Robotics in Smart Factories — ***12 Hour***

Introduction to smart factories - Overview of technologies used in smart factories – Role of artificial intelligence and robotics – Technological requirements – Challenges – Applications of artificial intelligence and robotics in smart factories – Real-world smart factories - Examples.
Experiments: 1. Introduction to programming language and software platforms for implementing AI algorithms and robot control. 2. Implementation of basic machine learning algorithms.

Unit-2: Robots for Smart Factories — ***12 Hour***

Industrial manipulators – Collaborative robots – Adaptive robots – Autonomous Guided Vehicles (AGV) – Autonomous Mobile Robots (AMR) – From AGV to AMR – Swarm robots – Technical considerations – Simultaneous Localization and Mapping (SLAM) – Real-world examples.
Experiments: 1. Implementation of part handling by a collaborative robot. 2. Implementation of control of an autonomous mobile robot.

Unit-3: AI Techniques for Smart Factories — ***12 Hour***

Artificial intelligence in the context of smart factories – Fuzzy logic – Machine learning algorithms and their applications in smart factories – Learning paradigms –Neural networks – Deep Learning for computer vision tasks in smart factories – Object recognition and detection for quality control and assembly.
Experiments: 1. Implementation of fuzzy logic control for a smart factory application. 2. Implementation of a deep learning algorithm for object recognition and detection.

Unit-4: AI-Enabled Automation and Optimization in Smart Factories — ***12 Hours***

Reinforcement learning for robot navigation, control, and optimization – AI in process control and automation – AI in condition monitoring and predictive maintenance – Intelligent scheduling and

resource allocation – Impacts of AI-enabled automation techniques and optimization strategies in smart factories. *Experiments: 1. Implementation of a reinforcement learning algorithm for mobile robot navigation and control. 2. Implementation of a machine learning algorithm for condition monitoring and predictive maintenance.*
Unit-5: AI Integration in IIoT ***12 Hours***
Integration of AI with IIoT systems – Advantages of AI integrated IIoT in smart factories – Data collection, analysis, and decision-making in smart factories – Real-time monitoring and optimization of manufacturing processes – Example. *Experiments: 1. Data collection and analysis from IIoT system. 2. Implementation of AI-driven process control on IIoT system.*

Learning Resources	1. *Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.* 2. *Souvik Pal, Debashis De and Rajkumar Buyya, "Artificial Intelligence-based Internet of Things Systems", Springer, 2022.*	3. *Dominik T. Matt, Vladimir Modrak and Helmut Zsifkovits, "Implementing Industry 4.0 in SMEs: Concepts, Examples and Applications", Palgrave Macmillan, 2021.* 4. *4. Anand Nayyar and Akshi Kumar, "A Roadmap to Industry 4.0: Smart Production, Sharp Business and Sustainable Development", Springer, 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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, Anna University pkarthikeyan@annauniv.edu*	1. *Mrs. G. Madhumitha, SRMIST*
2. Mr. Elayraj Jayaraj, Apple, USA	2. *Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	2. *Dr. R. Ranjith Pillai, SRMIST*

Course Code	21MHE473J	Course Name	DATA MODELING AND SIMULATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the various applications of modeling and simulation in IoT.*
CLR-2:	*acquire knowledge of the popular data modeling techniques.*
CLR-3:	*explore the simulation techniques in the data analytics used in IoT.*
CLR-4:	*acquire knowledge of the various performance measures used in the prediction algorithms.*
CLR-5:	*explore the AI techniques used in the data modeling and analytics.*

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 application of data modeling and simulation in IoT.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*apply the data modeling techniques in IoT applications.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*familiarize the simulation tools and methods in IoT data analytics.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*familiarize the performance measure and optimization tools in IoT data analytics applications.*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*apply the concept of machine learning in data analysis and prediction.*	*3*	-	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*2*

Unit-1: Application of data modeling and simulation in IoT — ***12 Hour***

Importance of data modeling and simulation in I4.0 - Data collection and management - Data preprocessing – Understanding behavior, performance, and optimization of IoT systems - data modeling and simulation for better analysis and prediction. Exp 1: Study on the application of data modeling and simulation. Exp 2: Organize and explore system data

Unit-2: Data modelling techniques — ***12 Hour***

Data modeling concepts and principles - time series data modeling- data aggregation, interpolation, and forecasting - data integration and fusion - Descriptive analytics, summarizing and visualizing data, including statistical methods, charts, and graphs - Predictive analytics, regression analysis, time-series analysis - Prescriptive analytics, optimization algorithms, and decision trees.
Exp 3: Preparing time series data (Signal pre-processing and filtering) Exp 4: Application of analytics: Descriptive/ Prescriptive / Predictive.

Unit-3: Simulation Techniques — ***12 Hour***

Network behavior, sensor interactions, data flows, simulation of sensor data streams and event-driven scenarios, validation of data against the real world.
Exp 5: Sensor data simulation and validation
Exp 6: Predictive modeling and output simulation

Unit-4: Performance Evaluation and Optimization — ***12 Hour***

Data Collection and processing time - Data Throughput and bandwidth - Latency, Response time, Security performance - Optimization: Edge computing, Data filtering and aggregation – Performance considerations for Predictive analytics and maintenance.
Exp 7: Study of various performance measures in data modeling.
Exp 8 : Study of performance measure and optimization in predictive analytics.

Unit-5: Emerging Trends and Future	***12 Hour***
Data modeling and analytics using machine learning and AI-driven simulations - Supervised learning, generative algorithms, Support Vector machines, Unsupervised learning, K means clustering, Expectation maximization - integration of data modeling with edge computing and cloud platforms. *Exp 9: AI tools for data generation and modeling.* *Exp 10: Data classification and prediction using machine learning methods.*	

Learning Resources	1. *Internet of things and data analytics handbook, Hwaiyu Ge, John Wiley & Sons, 2017* 2. *Matlab for data analysis: https://in.mathworks.com/products/matlab/data-analysis.html*	3. *Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", 2016, 2nd ed., Springer Verlag, UK* 4. *Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective" 2012, 1st ed., MIT Press, USA.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd	*1. Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	*1. Dr. R. Ranjith Pillai, SRMIST*
2. Mr. Ganesh Ram, Tunga Systems	*2. Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2. Dr. S Vasanth, SRMIST*

Course Code	21MHE474T	Course Name	FOUNDATIONS OF SYSTEMS ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce systems engineering concepts for solving the problems in developing complex engineering systems*
CLR-2:	*acquire knowledge in the domain of data management and processing in IoT.*
CLR-3:	*familiarize the various modeling approaches and methodologies*
CLR-4:	*analyze stakeholders' expectations using stakeholders value network*

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	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*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*develop various models for systems using Sys ML*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*analyze stakeholders' expectations using stakeholders value network*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*develop systems architecture for new or improved complex systems*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*use verification and validation techniques to evaluate the system design*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*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.	
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- focus on specialty areas (eg.. EMI/EMC)-test automation models (computation/timed automation)- simulation-model checking verification	
Unit-5: Systems Integration and Testing	***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 and verification- Ensuring System Functionality and Performance

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: CRCPress, 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)*				*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.Gaurav Dubey, Mathworks, India	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.Yogananda Jeppu, Honeywell, India	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.T.Muthuramalingam , SRMIST*

Course Code	21MHE475J	Course Name	SYSTEMS ARCHITECTURE AND DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce about system architecture and design*
CLR-2:	*acquire knowledge of the popular data modeling techniques.*
CLR-3:	*understanding the key concepts of architecture modelling*
CLR-4:	*analyze about systems requirements*
CLR-5:	*apply reusable structures for 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 system architecture and design concepts for solving the engineering problems*	*3*		*2*		*2*										*3*
CO-2:	*develop the key concepts of architecture modelling*	*3*		*2*		*2*										*3*
CO-3:	*analyze the needs of stack holders*	*3*		*2*		*2*										*3*
CO-4:	*develop design patterns and architectural styles*	*3*				*2*										*3*
CO-5:	*use trade-off analysis and decision making in system design*	*3*				*2*										*3*

Unit-1: Introduction about System Architecture and Design	***12 Hour***
Need of System design, Components of System design, System interfaces, Procedures for System design, Types of Architecture, Software Architecture	
Unit-2: Key Concepts of Architecture Modelling	***12 Hour***
System Architecture Model Elements, Information systems development, Web information systems, Behaviour modelling, Integrated modelling , Architecture frameworks	
Unit-3: Systems Requirements and Stake Holders Needs	***12 Hour***
Role of stake holders on systems design, Requirements analysis, deriving system requirements and use cases from stakeholder requirements. Artifacts, Specification of systems requirements	
Unit-4: Reusable Structures for System Design	***12 Hour***
Need for Evaluation of system design, Reusable Systems Design, Model-View-Controller (MVC), Agile Methodologies, Types of design patterns	
Unit-5: Trade-off Analysis and Decision Making	***12 Hour***
Need of Trade-off analysis, examples of trade-off analysis in systems engineering, Trade off analysis on decision making, Trade-off analysis Process, Case studies in Trade-off analysis, Steps involved in Decision management	

Learning	1. *National Aeronautics and Space Administration, "NASA Systems*	4. *Crowder, J.A., Carbone, J.N., Demijohn, R. (2016). Systems of Systems*

Resources	*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*	*Architecture Design. In: Multidisciplinary Systems Engineering. Springer, Cham.* *5. Rechtin, E., and M.W.Maier, "The art of Systems architecting", Boca Raton, FL: CRCPress, 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)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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.Gaurav Dubey, Mathworks, India	*1.1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.Yogananda Jeppu, Honeywell, India	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.T.Muthuramalingam , SRMIST*

Course Code	21MHE476J	Course Name	OBJECT PROCESS MODELLING AND SysML	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*Introduce Object Process Modelling and SysML*
CLR-2:	*acquire knowledge of the popular data modeling techniques.*
CLR-3:	*Understanding the Key Concepts of Object Process Modelling*
CLR-4:	*Analyze Comprehensive Overview and its Role in Object Process Modelling*
CLR-5:	*Apply Object Process Modelling in System Design and Development*

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 SysML concepts for solving the problems in developing complex engineering*	*3*				*2*										*3*
CO-2:	*Develop the Key Concepts of Object Process Modelling*	*3*				*2*										*3*
CO-3:	*Analyze Object Process Modelling using engineering tool*	*3*				*2*										*3*
CO-4:	*Develop Object Process Modelling for new or improved complex systems*	*3*				*2*										*3*
CO-5:	*Use Object Process Modelling with SysML in case studies*	*3*				*2*										*3*

Unit-1: OPM Conceptual Modeling	***12 Hour***
OPM Conceptual Modeling: Purpose and Context, Structure Modeling, MBSE methodologies, Structural and behaviour modeling using OPM,	
Unit-2: Advanced OPM Concepts	***12 Hour***
Object-Process Diagrams . language, Objects and processes, System Lifecycle and Evolution, Advanced OPM Concepts.	
Unit-3: SysML	***12 Hour***
SysML: Foundations and Diagrams; SysML Taxonomy, Use Case, Block, and State Machine Diagrams, SysML-Lite diagrams, relation between SysML and UML,	
Unit-4: Structural and behavioral modeling using SysML	***12 Hour***
SysML structural diagram, Five structural diagram, Package diagram and parametric diagram, SysML behavioral diagram, structural modelling,	
Unit-5: Systems and Traditional Engineering	***12 Hour***
Examples for systems engineering fields, Examples for systems engineering approaches, Life cycle systems engineering view, systems engineering and project management, Identifying complexities through different levels of abstractions and refinement, Examples of Engineered complex systems	

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: CRCPress, 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)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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.Gaurav Dubey, Mathworks, India	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.Yogananda Jeppu, Honeywell, India	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.T.Muthuramalingam , SRMIST*

Course Code	21MHE477J	Course Name	VERIFICATION AND VALIDATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Introduce about verification and validation in systems Engineering*
CLR-2:	*acquire knowledge of the popular data modeling techniques.*
CLR-3:	*Familiarize the VV activities*
CLR-4:	*Familiarize the VV methods*
CLR-5:	*Explore the method to model and optimize the VV process*

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 importance of VV in systems Engineering*	*3*				*2*										*3*
CO-2:	*Describe the VV activities*	*3*				*2*										*3*
CO-3:	*Analyze the VV methods*	*3*				*2*										*3*
CO-4:	*Describe the VV modeling and optimization techniques*	*3*			*2*	*2*										*3*
CO-5:	*Analyze the application of VV*	*3*			*2*	*2*										*3*

Unit-1 - Introduction to Verification and Validation in Systems Engineering	***12 Hour***
Verification and Validation (VV) VV problem statement VV systems and process, nature of mechatronics systems, VV concepts and definition, VV dilemma, modelling systems and VV lifecycle, Systems development lifecycle phases	
Unit-2 –VV Activities	***12 Hour***
Activities during: Definition, Design, Implementation, Integration, Qualification, Production, Use/Maintenance, Disposal	
Unit-3 - VV Methods	***12 Hour***
VV Methods for Non-testing: Requirements, verification matrix, system integration laboratory, hierarchical VV optimization, defect management and tracking, classification tree method, design of experiments. VV Methods for Testing: White box testing, black box testing: Basics, high-volume, special, environment, phase testing	
Unit-4 – Modelling and Optimizing VV Process	***12 Hour***
Modelling quality, cost, time and risk, quality data acquisition and aggregation, any one popular optimization method for cost and time	
Unit-5 – Detailed Case Study	***12 Hour***
Verification and Validation in Autonomous Driving and ADAS Systems: Design approaches for automated driving systems, different test approaches, scenario based testing, testing and qualification of perception software, functional safety and cybersecurity testing, VV Strategy: Test driven development and feature-driven development, test design and test depth, test suite, test process, testing in the vehicle., Acceptance criteria and maturity evaluation	

Learning	*1. Mourad Debbabi et al Verification and validation in Systems*	*3. Plato Pathrose, ADAS and Automated Driving: A Practical Approach to Verification and*

Resources	*Engineering, First Edition, Springer, 2010* *1. Anrew P. Sage, Verification, Validation, And Testing Of Engineered Systems, First Edition, Springer, 2010.*	*Validation, First Edition, SAE International, 2022.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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.Gaurav Dubey, Mathworks, India	*1.1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.Yogananda Jeppu, Honeywell, India	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.R Senthilnathan , SRMIST*

Course Code	21MHE478L	Course Name	CAPSTONE PROJECT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	6	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*Engage in high-level work focusing on an area of specialization where immersive technologies may be applied.*
CLR-2:	*Bridge theory and practice and are aimed to have an impact on the professional life of students.*

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

Nature of the Capstone Project

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

- *The Capstone Project provides an opportunity for students to engage in high-level work focusing on an area of specialization where IoT technology and systems engineering may be applied to a mechatronics system.*
- *Capstone projects (CP) will be inquiry and practice-centred.*
- *All Capstones aim to bridge theory and practice and are aimed to have an impact on the professional life of students.*
- *Students will identify the topics for their Capstone Project at the end of the sixth-semester study of the program.*
- *Capstone projects often take their inspiration from projects, papers, and experiences related to coursework in the degree program. However, to ascertain students' abilities for independent work and their capacity for self-directed inquiry, capstone projects must demonstrate in what ways individual graduate students have researched, developed, extended, or applied the ideas and strategies under investigation.*
- *Capstone Projects encourage the application of knowledge gained on teaching and learning throughout the degree program.*
- *Additionally, the Capstone Project should demonstrate the depth and extent of knowledge of students.*
- *Capstone projects should have hardware-involved work depending on the time, will, and the needs involved in the chosen application.*
- *The chosen project should ensure the integration of IoT and Systems Engineering in the application. It is mandatory to choose application involving both the fields*

Project Evaluation

The capstone project will be evaluated by a team of faculty members. The following points will be evaluated in each review.

- *BASIC KNOWLEDGE ABOUT THE FIELDS AND TOPICS RELATED TO THE PROJECT: (Basics of the fields of study related to the project in the context of what the student presented in the scope of the respective review)*
- *INTELLECTUAL CONTRIBUTION (Elements that the student presented which require the proper application of physics, mathematics, theory, etc)*
- *PROGRESS IN THE PROJECT TOWARDS THE CLAIMED OBJECTIVE (How much the student has progressed towards the claimed objective for the respective phase of the project)*
- *ACCOUNTABILITY OF TIME (How effectively the student has used the time towards the project and other activities that might help him/her do perform better in the project)*
- *Ability to understand, reason, and explain the ALLOWABLE elements of the project borrowed, outsourced, copied from the internet, etc*
- *TIMELY COMPLIANCE TO PROJECT RELATED FORMALITIES (Activities such as timely progress report submission, project report submission, etc)*
- *CONTENT OF THE PRESENTATION: Clarity and Supporting Data*
- *ORGANISATION OF THE PRESENTATION: Appropriate Media (such as images, videos, tables, flowcharts for illustrative purposes), Logical Flow of Slides and Smooth Transition Between Topics*
- *DELIVERY OF THE PRESENTATION: Professional, Confidence and Body Language, Clear Voice and Language with Good Pace, Engagement with Panel Members*

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

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.Yogananda Jeppu, Honeywell, India	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.R Senthilnathan , SRMIST*

Course Code	21MHE479J	Course Name	OPTIMIZATION TECHNIQUES IN SYSTEMS ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*formulate real life problems into optimization problems*
CLR-2:	*acquire knowledge of the popular data modeling techniques.*
CLR-3:	*gain knowledge of different optimization techniques*
CLR-4:	*explore applications of optimization techniques in systems engineering*
CLR-5:	*apply modern tools for solving optimization problems*

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:	*solve single- and multi-variables unconstrained optimization problems*	-	-	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*apply and analyze Linear Programming techniques to various applications*	-	-	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*apply and analyze Non-Linear Programming (NLP) techniques to various applications*	-	-	*2*	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*analyze challenges in Network optimization and solve different types of network problems*	-	-	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*analyze the challenges in global optimization and apply meta heuristic algorithms*	-	-	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*3*

Unit-1: Unconstrained Optimization — ***12 Hour***

Introduction to Unconstrained optimization problem. Objective function. Stationary points and extremum of a function. Single variable problems - Dichotomous and Golden-section search algorithms. Multi-variables problems, Gradient and Hessian of functions. Conditions for existence of solution. Steepest ascent method and Newton-Raphson algorithm.

Recommended lab exercises

1. *Solving unconstrained optimization problem – finding extremum of a function – symbolic & numerical*
2. *Solving unconstrained optimization problem – finding extremum of a function with Gradient – symbolic & numerical*
3. *Finding extremum of single variable function using Dichotomous (bisection) and Golden-section search algorithms*
4. *Finding extremum of single variable function using Newton-Raphson algorithm*

Unit-2: Constrained Optimization - Linear Programming (LP) — ***12 Hour***

Introduction. Classification of constrained optimization problem. Types of solutions. Introduction to Linear Programming (LP) – Problem definition – Solutions – Graphical solution, Simplex method.

Recommended lab exercises

5. *Solving Linear Programming problem – Graphical approach*
6. *Solving Linear Programming problem – Simplex method*

Unit-3: Constrained Optimization - Non-Linear Programming (NLP)	***12 Hour***
Introduction to Non-Linear Programming (NLP). Convex and concave functions. Multivariable optimization with constraints - Lagrange multiplier, Penalty function, Kuhn-Tucker condition of optimality *Recommended lab exercises* 7. *Solving NLP problem with multi-variables– finding optimal solution* 8. *Solving constrained NLP problem – symbolic and numerical - Lagrange multipliers* 9. *Solving constrained NLP problem – symbolic and numerical - Penalty function*	
Unit-4: Network Optimization	***12 Hour***
Network – graphs, definitions and terminology. Minimum spanning tree problem, shortest route problem. Maximum flow problem, Transportation problem (Travelling salesman, Chinese postman problems) *Recommended lab exercises* 10. *Application of minimum spanning tree problem and solution - Modelling and simulation* 11. *Finding solutions to shortest route problem - Modelling and simulation* 12. *Finding solutions to transportation and network-related problems - Modelling and simulation*	
Unit-5: Global Optimization	***12 Hour***
Local vs Global solution. Handling many variables and objectives. Introduction to bio-inspired and meta-heuristic approaches. Simulated Annealing, Particle Swarm optimization (PSO), Genetic Algorithm (GA). Pareto optimality. *Recommended lab exercises* 13. *Application of Simulated Annealing – Modelling and simulation* 14. *Application of PSO – Modelling and simulation* 15. *Application of GA - Modelling and simulation* 16. *Demonstration of Pareto optimality*	

Learning Resources	1. *Suresh Chandra, Jayadeva, Aparna Mehra, Numerical Optimization with Applications, Alpha Science International, 2009, ISBN: 1842654276* 2. *Hamdy A. Taha, Operations Research: An Introduction (9th Ed), Pearson, ISBN: 013255593X* 3. *Richard Bronson and Govindasami Naadimuthu, Schaum's Outline of Operations Research, McGraw Hill, ISBN: 9780070080201* 4. *Hanif D. Sherali Mokhtar S. Bazaraa, John J. Jarvis, Linear Programming and Network Flows, 2nd Ed, Wiley India, ISBN: 8126518928.*	5. *Deb K, Optimization for engineering design: Algorithms and examples, 2012, PH India, ISBN: 8120346785* 6. *Eligius M.T. Hendrix and Boglárka G.-Tóth, Introduction to Nonlinear and Global Optimization: 37 (Springer), ISBN: 1461425824* 7. *Rangarajan K. Sundaram, A First Course in Optimization Theory, Cambridge University Press, ISBN: 0521497701*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*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, India, mohammedsagheer.musthafa@wabco- auto.com*	1. *Dr Elango Natarajan, Department of Mechanical Engineering, UCSI University, Malaysia, elango@ucsiuniversity.edu.my*	1. *Dr Madhavan Shanmugavel, SRMIST*
2. *Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com*	*2. Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu*	2. *Dr. K Sivanathan, SRMIST*
		3. *Dr. T Muthuramalingam, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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