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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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	21MHE451J	Course Name	MANIPULATOR ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce industrial manipulators, configurations*
CLR-2:	*introduce a rigid body kinematics and dynamics related to industrial manipulator*
CLR-3:	*introduce forward kinematics of industrial manipulator*
CLR-4:	*introduce inverse kinematics and dynamics of industrial manipulator*
CLR-5:	*introduce trajectory planning and simulation of manipulator*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand types and configurations of industrial manipulators and specifications*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	*2*
CO-2:	*apply transformation matrices and dynamical equations to describe motion of a rigid body*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*derive forward kinematics of serial link manipulators and Jacobian matrix*	*2*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	*2*
CO-4:	*derive inverse kinematics, singularity dynamics of serial link manipulators*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	*2*
CO-5:	*design paths & trajectories for motion planning*	*2*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	*2*

Unit-1 – Introduction to Industrial Manipulators	***12 Hour***
Terms and definitions, types, configurations and workspace, SCARA, PUMA, STANFORD manipulators, OEMS and manipulator types and specifications	
Unit-2 – Kinematics and Dynamics of a Rigid Body	***12 Hour***
General motion of a rigid body and its matrix representation, transformation matrices and composite rotation, Euler angles and Quaternion. Dynamics of a rigid body, introduction to Newton-Euler and Lagrangian approaches of deriving equation of motion	
Unit-3 - Forward Kinematics	***12 Hour***
Geometric (direct) approach, Denavit - Harternberg (DH), Forward kinematics of planar & spatial manipulators and Jacobian matrix	
Unit-4 - Inverse Kinematics and Dynamics	***12 Hour***
Inverse kinematics and singularity of planar & spatial manipulators, challenges in calculating in inverse kinematics, dynamics (deriving equation of motions) of planar and spatial manipulators.	
Unit-5 - Relating Joint Space and Cartesian Space	***12 Hour***
Mapping joints – Motion to end effector motion, Trajectories – types, smoothness, kinematic profile, Point-To-Point (PTP) motion control, Continuous motion control, resolved rate control, motion planning	

List of Recommended Practical Experiments/Exercises	
1. Solving simultaneous linear equations and differential equations – symbolic 2. Solving simultaneous linear equations and differential equations – numerical 3. Modelling and simulation of motion of rigid body in 3D Cartesian coordinate system 4. Modelling and simulation of motion of rigid body in 2D Polar coordinate system 5. Modelling and simulation of motion of rigid body in 3D Cylindrical space 6. Rotation and Transformations calculations and visualization 7. Modelling and simulation of motion of rigid body in space applying Euler's angles 8. Computation of angle-axis for rigid body motion 9. Workspace calculations and visualization of a two-link planar manipulator – Applying forward kinematics	10. Workspace calculations and visualization of a SCARA manipulator – Applying forward kinematics 11. Workspace calculations and visualization of a PUMA manipulator – Applying forward kinematics 12. Workspace calculations and visualization of a STANFORD manipulator – Applying forward kinematics 13. Symbolic and numerical calculation for inverse kinematics of (i) two-link planar, (ii) SCARA, (iii) PUMA and (iv) STANFORD manipulators 14. Deriving conditions for singularities 15. Joint trajectory generation using, (i) linear, (ii) parabolic and (iii) cubic polynomials 16. Cartesian/Task space motion: (i) Point-to-Point control, Continuous and resolved rate controls 17. Motion-planning: Pick-and-Place, Obstacle avoidance, robot painting, robot welding, robot spraying

Learning Resources	
1. Craig John J., Introduction to Robotics: Mechanics and Control, Pearson Education; Fourth edition (2022), ISBN-10 : 9356062196 2. Ashitava Ghosal, Fundamental Concepts and Analysis (2006), ISBN:9780195673913 3. SK Saha, Introduction to robotics, Tata McGraw-Hill Education (2008), ISBN-10: 0070140014.	4. Schilling, Fundamentals of Robotics: Analysis and Control, PearsonEducation India (2015), ISBN-10: 9332555230. 5. William Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education; Sixth edition (2019),ISBN-10 : 9353065887s

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%	-
Level 2	Understand	50%	-	-	50%	25%	-
Level 3	Apply	50%	-	-	50%	30%	-
Level 4	Analyze	-	-	-	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	1. Dr Veera Ragavan Sampathkumar, Department of Robotics and Mechatronics engineering, Monash University (Malaysia campus), Malaysia	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 Ranjith Pillai, SRMIST

Course Code	21MHE452L	Course Name	COMPUTATIONAL THINKING LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop python programs for data visualization using object-oriented programming constructs*
CLR-2:	*explore various applications of linear algebra and calculus in robotics*
CLR-3:	*impart knowledge of different transforms and probability*
CLR-4:	*get exposed to various basic algorithms in general computing*
CLR-5:	*get awareness about computing principles through smart device application development practices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop computer programs for data visualization in python*	*3*	*2*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply various linear algebra and calculus methods in computing related to robotics*	*3*	*2*	*2*	-	*2*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze different transforms related to applications in robotics*	*3*	*2*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*define the algorithms used in general computing*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*develop applications for smart mobile devices to appreciate computing principles*	*3*	-	*2*	-	-	-	-	-	*1*	-	-	-	*2*	-	-

Unit-1 - Review of Python and Data Visualization — ***15 Hour***

Review of Datatypes, Operators, Data Containers, Conditional Statements, Iterative Loops, Functions and Scope of variables, Modules, File I/O, Error Handling, Classes and objects, Object oriented programming concepts, Plots for presenting comparison, Plots for presenting relationship, Plots for presenting distribution, Plots for presenting composition, 2D Animated Plots for Visualization, 3D Animated Plots for Visualization

Unit-2 - Linear Algebra, Calculus and Interpolation — ***15 Hour***

Vectors, matrix operations, matrix types and properties of matrices, Matrix and Array Operations, Eigen decomposition and application, Singular value decomposition and application, Pseudo inverse of a matrix, Solving system of linear equations, Numerical Differentiation in single variable and multiple variables, Newton-Cotes integration formulae, Multi-step application of Trapezoidal rule, Introduction to ODEs; Implicit and explicit Euler's methods Second-Order and Higher Order Runge-Kutta Methods, Stiff ODEs and Solving stiff ODEs – Practical Example, Solving transient PDE using Method of Lines, Error propagation, Global and local truncation errors, round-off errors, Linear least squares regression, Functional and nonlinear regression, Multi-variable regression, Interpolation using spline

Unit-3 - Transforms, Probability and Graph Theory — ***15 Hour***

Fourier transform, Discrete Fourier transform, DFFT using DSO Data, 2-D Fourier transform, 2D Discrete Fourier transform, Image Smoothing in Frequency Domain, Image Sharpening in Frequency Domain, Introduction to Laplace transforms, Laplace transforms of standard functions, Convolution theorem of Laplace transform, Initial and final value theorem of Laplace transform, Applications of Laplace transform, Z-Transform, Basics of Probability, Exercise Markov Probability Problem, Foundations of graph theory, Problem based on Adjacency matrix

Unit-4 - Algorithms — ***15 Hour***

Peak Finding, Computation Models – Producer Consumer, Computation Models – Master-Slave, Computation Models – State-Machine, Stack, Queues Random Access, Pointer Models of Computation, Sorting – Merge Sort, Sorting – Heap Sort, Binary Search, Finding maximum, minimum, value Introduction to Shortest Path problem, Dijkstra Method, Understanding Computational Complexity, Measuring algorithm's performance in time and accuracy

Unit-5 - Mobile Application Development and Cased Studies	***15 Hour***
Introduction to MIT App Inventor, Basics of Programming Environment, Programming Basics, Dialogs, Alarm Clock Application, Alarm Clock Application Audio Processing Application, Audio Processing Application, Video Processing Application, Video Processing Application, Device Location based Application, Device Location based Application, Sensor Data Processing, Complete Application Study of Software Stack in a Automation Application	

Learning Resources	1. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques for3D Computer Vision", 1st Edition, Prentice Hall, 1998 Edition.* 2. *WileyForsyth and Ponce, Computer Vision: A Modern Approach,2nd Edition, Pearson, 2015.*	3. *Chapra S.C. and Canale R.P. Numerical Methods for Engineers, 5th Ed.,McGraw Hill, 2006* 4. *Erwin Kreyszig, Advanced Engineering Mathematics, Wiley, 10th Edition,2015.* 5. *MIT App Inventor Course Materials*

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. Mohammed Sagheer, ZF Wabco TechnologyCenter, mohammedsagheer.musthafa@wabco- auto.com*	1. *Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Shankar Bharathi, Larsen & Toubro TechnologyServices, shankarbharathi.s@ltts.com*	2. *Dr. Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	2. *Dr. K. Sivanathan, SRMIST*

Course Code	21MHE453J	Course Name	MECHANICS OF MANIPULATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	21MHE451J	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	impart the concept of inverse kinematics and its computation method for various configurations of Robot
CLR-2:	impart the concept of Jacobian and its computation
CLR-3:	gain knowledge in statics and trajectory planning in manipulator robots
CLR-4:	gain knowledge in the derivation of dynamic model for serial manipulator
CLR-5:	expose the students to various control strategies used in the manipulator

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	apply the learning to compute inverse kinematics of the manipulators	3	3	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	derive the Jacobian matrix for the serial manipulators and compute the singularity condition	3	3	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	apply the concept of statics in manipulators and trajectory planning in manipulators	3	3	3	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	derive the dynamic model of a planar arm manipulator	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	understand the design and implementation of popular position and force control schemes used in industrial manipulators	3	2	2	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Inverse Kinematics **12 Hour**

Review of Forward Kinematics, Forward kinematics of a 6 DoF Manipulator (using values from datasheet), Introduction to inverse kinematics, Complexity and Issues in inversekinematics computation, General methods to solve inverse kinematics and conditions, Inverse kinematic solution for 2R planar arm using geometric method, Inverse kinematics Computation- Closed loop solution, Inverse kinematics solution for spherical wrist using closed form method, Inverse kinematics of 3 DoF arm using closed form method, Computation consideration for inverse kinematics, example. Use of inverse kinematic model in manipulator control

Unit-2 - Manipulator Jacobian **12 Hour**

Description/Notation for time varying position and orientation, Linear velocity for rigid bodies, Angular velocity for rigid bodies ,Relationship between transformation matrix and angular velocity, Velocity propagation along links: Linear velocity ,Velocity propagation along links: Angular velocity, Concept of Manipulator Jacobian, Importance of Jacobian matrix, Concept of linear and angular velocity Jacobian , Linear velocity Jacobian of RR planar arm, r and angular velocity Jacobian computation for spherical wrist , Jacobian Computation for RRR spatial manipulator, Concept of Singularity in manipulator , different types of singularity , Singularity computation in manipulator and its consequences , Singularity condition for RPY spherical wrist , Physical interpretation of singularity condition , Singularity condition for RRR spatial manipulator , Physical interpretation

Unit-3 - Statics and Trajectory Planning **12 Hour**

Static forces in manipulators , Static analysis for single link, Jacobian in Force domain, Jacobian in statics, Static force computation of a planar RR manipulator, Static force computation of spatial RRR arm, Cartesian transformation of velocities and static forces, Introduction to Trajectory Planning , Joint space and Cartesian space : Application in control, Joint space trajectory planning: Example of cubic polynomial , Joint space trajectory planning via points , Cartesian space trajectory planning :Example, Problem in Cartesian space planning.

Unit-4 - Manipulator Dynamics	**12 Hour**
Introduction to dynamics , Dynamic terms: Inertia tensor, centrifugal force, Coriolis force, gravitational forces , Understanding dynamics of a simple system- mass spring damper system, Concept and importance of Inverse and forward dynamics , Lagrangian formulation for dynamic model , Steps in Lagrangian-Euler (LE) method , Dynamic model of a RR Planar manipulator using LE method , Newton-Euler Formulation: Steps in Newton Euler method, Dynamic model of a RR Planar manipulator using NE method, Dynamic model of an RP planar arm, Computing dynamic model of the pendulum over a cart, Application of dynamic model in analysis and control	
Unit-5 - Introduction to Robot Control	**12 Hour**
Review of Position control, PID control of one DoF link with DC motor , Jacobian in control: resolved rate control , Example: 1D resolved rate control Concept of partition control (Model based) : Example of PPID control , Concept of computed torque control in manipulators :Example with a general dynamic model ,Simulation for computed torque control for 2R planar arm , Comparison with PID control, Introduction to force control , Application of force control in manipulators with example of force control of mass spring system, Framework for force/position control , Concept of natural and artificial constraints: Solving for natural and artificial constraints for various process, Hybrid force position control strategy : with example	

List of Recommended Practical Exercises

1. *Basics of Linear Algebra and transformations- Review.*
2. *Manipulator Development and simulation.*
3. *Forward kinematics exercise: simulated motion with the manipulator, workspace simulation.*
4. *Inverse Kinematics exercise: Simulation with an example of multiple solutions.*
5. *Jacobian and singularity computation in manipulators.*
6. *Joint space and cartesian space trajectory planning, the effect of singularity in trajectory planning.*
7. *Dynamic model and simulation: understanding the effect of gravity and other forces on the manipulator.*
8. *Physical modeling of 1 DoF link.*
9. *PID control of 1 DoF link.*
10. *Computed torque control of 1 DoF link.*

Learning Resources

1. *John J. Craig, "Introduction to Robotics Mechanics and Control",3rd edition, Pearson, 2008.*
2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics andControl", 2nd edition, Wiley India, 2008.*
3. *Saeed B.Niku, "Introduction to Robotics Analysis, Systems andApplications", 2nd edition, Prentice Hall of India, 2009.*
4. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5thedition, Prentice Hall of India Learning, 2009.*
5. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, TataMcGraw Hill, 2007.*
6. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision andIntelligence", 1st edition McGraw Hill, 2008.*
7. *Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition,MIT Press, 2003*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (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*	-	-	-	*15%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21MHE454J	Course Name	GROUND MOBILE ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*articulate the locomotion aspects and mobility of various mobile robot configurations*
CLR-2:	*derive the kinematic models for various robot configurations*
CLR-3:	*develop algorithms of localization and mapping*
CLR-4:	*apply various path planning algorithms*
CLR-5:	*create motion control algorithms for the safe navigation of mobile robots*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the locomotion aspects and mobility of various mobile robot configurations*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	*1*	*1*
CO-2:	*develop the kinematic models for various robot configurations*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	*2*
CO-3:	*implement algorithms of localization and mapping*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	*2*
CO-4:	*apply various path planning algorithms*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	*2*
CO-5:	*implement motion control algorithms for the safe navigation of mobile robots*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	*2*

Unit-1 - Introduction — ***12 Hour***

Introduction, Mobile vs. Manipulator robots, Locomotion aspects, Controllability, stability and maneuverability, Types of wheels, Degrees of freedom, mobility, steerability and maneuverability, Derivation of wheel kinematic constraints of standard and steerable standard wheel, Mobility analysis of differential drive and car-like robot, wheeled robot configurations, Mobility analysis of various configurations, DOF, DDOF, and Holonomic vs. non-holonomic configuration comparison.

Unit-2 - Kinematics of Mobile Robots — ***12 Hour***

Differential kinematics, Comparison between manipulator robot vs. mobile robot kinematics, Derivation of forward and inverse kinematics of differential drive robot based on wheel kinematics constraints, Interpretation of the derived model through geometric observation, Derivation of forward and inverse kinematics of uni-cycle model based on wheel kinematics constraints, Interpretation of the derived model through geometric observation, Derivation of forward and inverse kinematics of car-like robot based on wheel kinematics constraints, Interpretation of the derived model through geometric observation, Kinematic calibration of car-like robot, Limitation of kinematics-only models Introduction to dynamic modelling of ground mobile robots.

Unit-3 - Localization and Mapping — ***12 Hour***

Challenges in localization, Sensor noise, aliasing, approximations, Belief representation in maps, hidden state, Types of belief representation and comparison, Gaussian theory, Gaussian belief representation, Bayes rule and Bayesian filter, Odometry model, Basics of optimal state estimation, Kalman Filter, Extended Kalman Filter (EKF), EKF based localization.

Unit-4 - Path Planning — ***12 Hour***

Basics of maps, Types of maps, Challenges in path planning, Global vs. local path planning, Types of path planning algorithms, Heuristics based search algorithm for global planning, Local path planning algorithm, and Trajectory generation.

Unit-5 - Motion Control — ***12 Hour***

Sampling concepts, Sensor update rates and variability, Trajectory smoothing requirements, Via points slicing and consideration, Longitudinal vs. lateral control PID model, PID control of longitudinal motion, PID tuning and implementation details, Pure pursuit control for lateral movement, Stanley controller for lateral movement.

List of Recommended Practical Exercises	
1. *Animating a robot motion using a general spatial transformations.* 2. *Kinematic modelling of differential drive and car-like robot* 3. *Gaussian Belief representation and properties and conditional probability.* 4. *Linear Kalman filter basics.* 5. *IMU and GPS data processing*	6. *EKF localization.* 7. *Occupancy grid-based map creation and updation.* 8. *High-level API based map creation and update(Open route service, Google Maps API based)* 9. *Global path planning in occupancy grid and high level API* 10. *Introduction to autonomous driving simulation software*

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

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (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. *Dr.Guna Surendra, Hitachi, Japan*	1. *Dr. P. Karthikeyan, MIT Campus, Anna University,pkarthikeyan@annauniv.edu*	1. *Dr. K Sivanathan, SRMIST*
2. *Mr. Elayraj Jayaraj, Apple, USA*	2. *Dr. Thiyagarajan, Indian Institute of Technology Tirupati,thiyagu@iittp.ac.in*	2. *Dr. R Senthilnathan , SRMIST*

Course Code	21MHE455T	Course Name	ROBOT CONTROL	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 general industrial manipulator control problem*
CLR-2:	*provide knowledge on various position control strategy used in the industrial manipulator*
CLR-3:	*impart the concept and strategy of force control in manipulators*
CLR-4:	*introduce various adaptive control strategy applied to industrial manipulators*
CLR-5:	*introduce popular intelligent controllers applied to industrial manipulators*

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:	*define the various control architecture used in industrial manipulator*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*design and formulate various position control strategies applied for the manipulator*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*design and formulate various force control strategies applied for the manipulator*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*apply the concept and design of adaptive controllers applied to manipulator robots*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*apply the concept and design of intelligent controllers applied to manipulator robots*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction to Manipulator Control Problem — ***9 Hour***

General manipulator control system architecture , Manipulator control problem , Joint space and task space control , Task space and joint space mapping, Open and closed loopcontrol : Advantages and disadvantages in their application in Robots, Linear and nonlinear control, Linear control schemes , Second-order system and its characteristics, Position Regulation of second order system, SISO and MIMO systems , Continuous and discrete time control, Sampling and sample rate, Industrial Robot control architecture: ABB IRC5controllers.

Unit-2 - Position Control of Manipulators — ***9 Hour***

General Dynamic model of the manipulator, Model of a 1 DoF joint along with an actuator (DC motor), PI, PD control of 1 DoF joint - Implementation and key considerations, PID control of 1 DoF joint - Implementation and key considerations, Control law partitioning , Block diagram of partitioned control law Partitioned PD control scheme for 1 DoF rotary joint, Selection of PD gains in Partitioned PD control scheme, Effect of external Disturbance, Disturbance rejection in trajectory following control, Computed torque control for the manipulator, Resolved Rate control: Discussion with example (2D).

Unit-3 - Force Control of Manipulators — ***9 Hour***

Force control of Robot manipulators, Framework for the force control scheme , Define- Artificial and natural constraints, Case study to define artificial and natural constraint , Description of force control task : Example- Peg in-hole assembly , Force control of the mass-spring system, Practical implementation consideration for the force control, Introduction to hybrid force position control problem, Hybrid force/position control architecture, Selection matrices, Case study for hybrid force position control scheme, Impedance force/torque control, Application of impedance control system for n DoF manipulator Example of impedance control along with the position control in loop.

Unit-4 - Adaptive Controllers — ***9 Hour***

Introduction to adaptive controllers and advantages, Types: model reference, self-tuning, Linear perturbation adatptive control, Lyapunov stability theorem and its concept, Stability analysis: Example, Variable Structure control - Example: Sliding mode control applied to manipulator robots, Adaptive Computed torque controller, Fuzzy tuning PID gains based controller, Estimator based disturbance rejection method –Robustness to adaptive controller .

Unit-5 - Intelligent Controllers	***9 Hour***
Introduction to fuzzy control: Discussion- Elements of Fuzzy control, Example of application of Fuzzy based control for MIMO systems , Considerations for the Fuzzy based controller, Neural network control of Robots, Neural Network background, Multilayer neural network, Neural Net feedback tracking controller , Neural net controller gains and architecture, Back propagation weight tuning.	

Learning Resources		
	1. *John J. Craig, "Introduction to Robotics", Addison Wesley, ISE2008.* 2. *R.K Mittal and I J Nagrath, "Robotics and control "T a t a McGraw Hill, 2014.*	3. *Frank L Lewis, Darren Dawson, Chaouki Abdallah, "Robot Manipulatorand control: Theory and Practice" Marcel Dekker, 2010.* 4. *Michael Negnevitsky,"Artificial intelligence", 2nd edition, Addison Wesley.*

Learning Assessment

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

Course Designers

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

Course Code	21MHE456J	Course Name	VISION GUIDED ROBOTS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the specifications of various vision hardware*
CLR-2:	*experiential learning of various image processing and analysis algorithms*
CLR-3:	*get introduced to passive and active methods of 3D scene reconstruction*
CLR-4:	*to get exposed to visual odometry and V-SLAM methods*
CLR-5:	*to appreciate the various visual servoing architectures applied to robot manipulators*

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:	*choose the various vision hardware for an application*	*3*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*develop Image Processing and Analysis Algorithms*	*3*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-3:	*implement 3D reconstruction techniques*	*3*	*2*	*2*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-4:	*create odometry and SLAM algorithms*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*-*
CO-5:	*compile various visual servoing techniques*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*	*-*	*2*	*-*	*-*

Unit-1 - Vision Hardware	***12 Hour***
Introduction to Vision, Comparison of biological and computer vision, Scene constraints, Light sources, Lighting techniques, Optical Filters, Lens specifications, Selection Image sensors and specifications, Advanced sensor technologies, Camera computer interfaces, Computing considerations	
Unit-2 - Image Processing and Analysis	***12 Hour***
Vision software basics and Types and selection, 2D Convolution, Image smoothing in spatial domain, Image sharpening and Edge detection in spatial domain Color image processing, Morphological Image Processing, Region Features and Classification - types, Scale Invariant Feature Transform (SIFT) key point descriptor Scale space construction and difference of Gaussian, Matching Algorithms, Gray-level and correlation based matching Descriptor based matching	
Unit-3 - 3D Reconstruction	***12 Hour***
Geometric Camera Modelling, Camera Calibration, Derivation Geometry of a stereo vision system, Estimation of fundamental and essential matrix, Epipolar constraint, Epipolar rectification, Metric reconstruction, Structured Light reconstruction, Principle, working and specifications , LIDAR, Principle, working and specifications	
Unit-4 - Optical Flow, Visual Odometry and SLAM	***12 Hour***
Formulation of the motion analysis, Motion field of rigid objects, Optical flow and Motion field, Estimating motion field - differential techniques, Estimating motion field - feature based techniques, Monocular and Stereo Visual Odometry, Review of Kalman Filter Basics, EKF basics , Visual Inertial Odometry using EKF, VSLAM, VSLAM approaches, VSLAM approaches	
Unit-5 - Visual Servoing	***12 Hour***
Mathematical formulation of visual servo problem, Classification of visual servoing architectures, Image based visual servoing (IBVS), interaction matrix derivation, Geometrical interpretation of IBVS, stability analysis, Position based visual servoing, Pose based motion, Calibration for visual servoing systems Calibration for visual servoing systems, Hybrid visual servoing, partitioned visual servoing, switching schemes in visual servoing	

List of Recommended Practical Exercises
1. *Image Acquisition – Different Modes and Performance Analysis*
2. *Working with Specifications of Lenses and Imaging Sensors, Interface and bandwidth studies for cameras*
3. *Sampling, Quantization, Image I/O, Image Histogram, Thresholding, Contrast Stretching*
4. *Gaussian Image Smoothing, Edge Detection (Gradient, Laplacian and Canny) and Order statistical Filters*
5. *HIS Filtering, morphological Operations (Erosion, Dilation, Opening and Closing) , Region feature Extraction and Classification in Binary Image*
6. *SIFT key point descriptor and matching, Region based matching*
7. *Camera calibration, Computational Stereo Vision for 3-D scene reconstruction in Indoor Scenes*
8. *Structured light reconstruction*
9. *RGB data and LIDAR data correspondence in Outdoor Scenes*
10. *Optical flow estimation using Lucas-Kanade and Farneback methods in Outdoor Scenes*
11. *Monocular and Stereo Visual Odometry in Outdoor Scenes*
12. *Visual Inertial Odometry in Outdoor Scenes*
13. *Visual SLAM in Outdoor Scenes*
14. *Image Based Visual Servoing in Manipulator*
15. *Position based Visual Servoing in Manipulator*

Learning Resources	1. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing,4th Edition, Pearson Education", 2018* 2. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques for3D Computer Vision", 1st Edition, Prentice Hall, 1998 Edition.* 3. *Alexander Hornberg, "Handbook of Machine Vision", 2nd Edition,Wiley, 2006 Edition.*	4. *WileyForsyth and Ponce, Computer Vision: A Modern Approach,2nd Edition, Pearson, 2015.* 5. *Peter Corke, Robotics, Vision and Control, Second Edition,Springer, 2017*

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. *Mr. Mohammed Sagheer, ZF Wabco TechnologyCenter, mohammedsagheer.musthafa@wabco-auto.com*	1. *Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Shankar Bharathi, Larsen & Toubro TechnologyServices, shankarbharathi.s@ltts.com*	2. *Dr. Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	2. *Dr. K. Sivanathan, SRMIST*

Course Code	21MHE457L	Course Name	ROBOT PROGRAMMING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	5	3

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

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

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

Unit-1 - Industrial Robot Programming Using RAPID — ***15 Hour***

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

Unit-2 - Introduction to ROS — ***15 Hour***

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

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

Installing ROS Packages for ABB Yumi, Network Setup, Firmware setup and Setup of Yumi Controller, Griper Setup , Setup YuMi ROS Interface through TouchPendant, Running Task and Handling errors , Introduction to programming and simulation using Robot studio, Control Interfaces – Position Control, Gripper Control , Starting RAPID Scripts, Live Nodes and MoveIt Vision Based Closed Control of Single arm for Pick and Place Task , Vision Based Closed Control of Single arm for Pick and Place Task, Dual arm manipulation for an assembly task , Dual arm manipulation for an assembly task , Interfacing Dobot-Magician manipulator to ROS, Understand service-programming and creating a server and client in ROS for Dobot magician , Programming for Point-to-Point motion – 1, Programming for Point-to-Point motion – 2, Programming for Continuous motion – 1 , Programming for Continuous motion – 2 , Programming for Continuous motion - 3

Unit-4 - Mobile Robot Perception and Localization — ***15 Hour***

Wheel Odometry, PID heading control of the robot, PID longitudinal control of the robot, Camera modelling and homographs, Camera calibration Lane marking detection, Visual servo control for lane following, Map building , Visual odometry, Interfacing of range sensor and IMU, Understanding Kalman Filter Sensor fusion with EKF, Visual inertial odometry, Object detection

Unit-5 - Mapping, Motion planning and Control	***15 Hour***
Map Considerations, Types, Access - ,Global Path Planning – A , Global Path Planning – PRM, Global Path Planning – RRT , Control in Obstacle-free Environment Map update environmental objects with manual jogging , Local planning -Bug Algorithm Variants, Local planning – VFH , Motion Planning and Control in Dynamic Environment, Reinforcement learning based navigation*	

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

Learning Assessment

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

Course Designers

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

Course Code	21MHE458T	Course Name	MODEL BASED SYSTEMS ENGINEERING FOR ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21MHC307P	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:	*review the Concepts of Model Based Systems Engineering*
CLR-2:	*apply the concepts of MBSE in developing manipulator / autonomous ground vehicles*
CLR-3:	*apply the concepts of MBSE in developing Aerial robots*
CLR-4:	*apply the concepts of MBSE in developing Aquatic robots*
CLR-5:	*apply the concepts of MBSE in developing medical robots*

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:	*review the Concepts of Model Based Systems Engineering*	*3*	*3*	*-*	*1*	*-*	*1*	*-*	*-*	*-*	*2*	*-*	*-*	*2*	*2*	*2*
CO-2:	*apply the concepts of MBSE in developing manipulator / autonomous ground vehicles*	*3*	*3*	*-*	*3*	*3*	*3*	*-*	*-*	*3*	*3*	*-*	*-*	*3*	*3*	*3*
CO-3:	*apply the concepts of MBSE in developing Aerial robots*	*3*	*3*	*3*	*3*	*3*	*3*	*-*	*-*	*3*	*3*	*2*	*-*	*3*	*3*	*3*
CO-4:	*apply the concepts of MBSE in developing Aquatic robots*	*3*	*3*	*3*	*3*	*2*	*3*	*-*	*-*	*3*	*3*	*2*	*-*	*3*	*3*	*3*
CO-5:	*apply the concepts of MBSE in developing medical robots*	*3*	*3*	*3*	*3*	*2*	*3*	*-*	*-*	*3*	*3*	*2*	*-*	*3*	*3*	*3*

Unit-1 - Review of MBSE Concepts	***9 Hour***
Stakeholders Analysis, Requirements definition, Concept Generation, Creating Architecture, Verification and Validation	
Unit-2 - Application of MBSE in Ground Robots Development	***9 Hour***
Manipulator / Autonomous Ground robot development: Stakeholders Analysis, Requirements definition, Concept Generation, Creating Architecture, Verification and Validation	
Unit-3 - Application of MBSE in Aerial Robots Development	***9 Hour***
UAV fixed wing / Rotary wing development: Stakeholders Analysis, Requirements definition, Concept Generation, Creating Architecture, Verification and Validation	
Unit-4 - Application of MBSE in Aquatic Robots Development	***9 Hour***
Autonomous Under water Vehicle/ Autonomous Surface Vehicle development: Stakeholders Analysis, Requirements definition, Concept Generation, Creating Architecture, Verification and Validation	
Unit-5 - Application of MBSE in Surgical Robots Development	***9 Hour***
Surgical robot development: Stakeholders Analysis, Requirements definition, Concept Generation, Creating Architecture, Verification and Validation	

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)*				*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. Ranjith Pillai , SRMIST*

Course Code	21MHE459J	Course Name	PLANNING AND DECISION MAKING IN ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*demonstrate the planning problem as a search algorithm*
CLR-2:	*provide an overview of different planning approaches relevant to Robotics*
CLR-3:	*provide fundamentals knowledge in process of decision making and techniques*
CLR-4:	*formulate the problems of detection, and localization in robotics*
CLR-5:	*give basics of implementing algorithms through simulations*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*formulate the planning problems as a search algorithm in discrete space*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*understand different types of motion planning with and without constraints*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*apply decision making techniques to robot applications*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*estimate and localize the position of a mobile robot applying Bayesian and Kalman filtering*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*modelling planning and decision-making problems in robotics*	-	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Planning as a Process and its Applications	***12 Hour***
Planning: {Execution, refinement and inclusion}, search algorithms and Metrics, BFS, DFS, Heuristic search algorithms, Dijkstra, A-Star, Optimal path search, Dynamic programming	
Unit-2 – Robotics Configuration Space and Obstacle Avoidance	***12 Hour***
Motion planning algorithms: Roadmap methods: Visibility graph and Voronoi diagram, Cell decomposition and RRT, Sample based and Potential field approaches, Constraints, Planning under differential constraints, Kinematics of two-wheeled differential drive mobile robota	
Unit-3 - Decision Making	***12 Hour***
Decision trees, Decision matrix, Linear Programming, Game theory, Statistical approaches, Bayesian approach	
Unit-4 - State Estimation	***12 Hour***
State and measurement uncertainties, Conditional probability and Bayes theorem, Belief function, Markov process and state transition, Recursive Bayes filter, Obstacle detection & Bayes filter, State estimation using Bayes filter	
Unit-5 - Kalman Filtering (KF)	***12 Hour***
State estimation using Linear Kalman Filtering (LKF) – algorithm, Robot localization - Formulation of/for: probabilistic kinematic model, Position calculation, algorithm for odometry, Orientation calculation, Robot localization - Algorithm for probabilistic kinematic model	

List of Recommended Practical Experimental / Exercises	
1. *Shortest path finding using BFS search* 2. *Shortest path finding using DFS search* 3. *Shortest path finding using heuristic search* 4. *Shortest path finding using Dijkstra search* 5. *Shortest path finding using A-star search* 6. *Shortest path finding using dynamic programming* 7. *Path search: Road map methods (i) Visibility graph, (ii) Voronoi, (iii) Cell-decomposition, (iv) RRT* 8. *Path search: Sample based methods* 9. *Path search: Potential field method*	10. *Differential constraint-based path planning* 11. *Motion-planning: (i) Localization, (ii) Probabilistic kinematic model* 12. *Dubins path-based path planning* 13. *Cubic polynomial-based path planning* 14. *Path replanning using decision algorithms based on: (i) Linear programming, (ii) Game theory, (iii) Bayesian approach* 15. *Kalman filter estimation of: (i) distance (ii) velocity* 16. *Kalman filter estimation of: (i) state, (ii) measurements: odometry* 17. *Probability of obstacle detection: Bayes' belief function*

Learning Resources		
	1. *Planning algorithms by Steven M. LaValle, Cambridge University Press, ISBN-13: 978-0521862059, http://lavalle.pl/planning/, http://lavalle.pl/ (2006)* 2. *Sebastian Thrun, Wolfram Burgard and Dieter Fox, Probabilistic Robotics, The MIT Press, ISBN-13: 978-0262201629, http://www.probabilistic-robotics.org (2005)* 3. *Alonzo Kelly, Mobile Robotics - Mathematics, Models, and Methods, Cambridge University Press, (2013)*	4. *Anis Koubaa , et al, Robot Path Planning and Cooperation - Foundations, Algorithms and Experimentations, ISBN: 978-3-030-08355-7,(2019)* 5. *Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition) 3rdEdition, Pearson Education, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	-	-	-	*20%*	-
Level 2	*Understand*	*60%*	-	-	*50%*	*55%*	-
Level 3	*Apply*	*40%*	-	-	*50%*	*25%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com*	1. *Prof Arpita Sinha, Indian Institute of Technology, Mumbai, India*	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 Ranjith Pillai, SRMIST*

Course Code	21MHE460T	Course Name	ADVANCED ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart knowledge in the area of parallel manipulators*
CLR-2:	*impart the concepts and challenges involved in multi-robot systems*
CLR-3:	*provide fundamentals of modeling and control of flexible robots*
CLR-4:	*introduce the various complexities of wheeled mobile robots in uneven terrain*
CLR-5:	*introduce the advanced concepts of robotics like a cooperative robots, haptics, and tele robotic systems*

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:	*derive the inverse kinematics and Jacobian of parallel manipulator*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*understand the concept of multi-robot systems and their control challenges*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*apply the concepts of modeling and control of flexible robots*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*apply the mathematical concepts of modeling and control of wheeled mobile robot in uneven terrain*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*understand the fundamentals of the cooperative robot, haptics, and tele robotic systems*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Parallel Mechanisms — ***9 Hour***

Definitions, Configurations and types, Degree of freedom computation, Inverse kinematics approach for a spatial parallel manipulator, Jacobian computation method using vector loop equation, singularity computation, types and causes of the singularity, Introduction to forward kinematics and computation method, Study of pneumatically driven and wire driven parallel robot (any DoF)

Unit-2 - Multi-Mobile Robot systems — ***9 Hour***

Introduction to multi-robot systems, Architecture for multi-robot systems, Communication systems and strategies, Networked Mobile Robots: Control methods, Communication for control, Communication for perception, control for communication, Introduction to swarm robots, Introduction to modular robotics, Application

Unit-3 - Control of Flexible Manipulators — ***9 Hour***

Robots with Flexible joints, Dynamic model of link with flexible joints, regulation control, PD control with gravity compensation, Robot with flexible links, design issues and considerations, Modelling of flexible arms, Sensors for flexibility control, command shaping algorithm for control, Insight to feedback control of flexible link manipulators.

Unit-4 - Wheeled Mobile Robots — ***9 Hour***

Introduction to wheeled mobile robot (WMR), Dynamic of mobile robot, Two and three-wheeled WMR on flat surfaces , Wheel terrain interaction mechanics, Concepts of Slip,
Slip Modelling, WMR on uneven terrain, and Design of Slip free motion on uneven terrain, Control of wheeled robot in rough terrain: slip compensated path follower, Introduction to modeling and control of tracked vehicle: control of sub tracks.

Unit-5 - Advanced Topics — ***9 Hour***

Introduction to cooperative Manipulators, Historical overview, Control of cooperative manipulator: Overview, Introduction to Haptics, Application of Haptics, Haptic Device Design: Actuator and sensor selection, Popular haptic device , Haptic Rendering, Haptic control loop, Overview of Impedance control, Control and stability of haptic interfaces, Introduction to tele robotic systems: actuators and sensor requirements, Application, Control Architecture, Bilateral control and force feedback, Communication and networking.

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control",3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics andControl", 2nd edition, Wiley India, 2008.*	3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.Siciliano, B., and Khatib, O. (Editors), Handbook of Robotics, Springer, 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*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

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

Course Code	21MHE461J	Course Name	AI FOR PERCEPTION PLANNING AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*obtain motivation for artificial intelligence and machine learning*
CLR-2:	*analyze the mathematics behind fuzzy logic for decision making*
CLR-3:	*get exposed to classical and convolutional neural networks and deep learning philosophy*
CLR-4:	*realize various convolutional neural network architectures that are applied for computer vision tasks*
CLR-5:	*explore the applications of reinforcement learning in planning and control tasks*

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

Unit-1 - Introduction to AI & ML — ***12 Hour***

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

Experiments:

1. Implementation of classification algorithm and its performance evaluation, 2. Linear regression algorithm and computation of its performance metrics.

Unit-2 - Fuzzy Logic — ***12 Hour***

Introduction to fuzzy logic - Overview of Classical sets, their properties, and operation - Fuzzy set theory, properties of fuzzy sets and their operations - Fuzzy composition - Numerical examples - Membership functions - Fuzzy rule generation - Fuzzification and defuzzification - Fuzzy inference system - Example case studies for mobile robot navigation and manipulator control.

Experiments:

1. Fuzzy logic control for mobile robotics application, 2. Fuzzy logic implementation for manipulator control.

Unit-3 - Classical and Convolutional Neural Networks — ***12 Hour***

Overview of biological neuro-system - Single layer perceptron - Learning rules - Multilayer perceptron - Backpropagation - Introduction to neuro-fuzzy system - Architecture of neuro-fuzzy networks - Classical neural networks vs. deep learning - Convolutional neural networks - Activation functions - Optimization techniques - Deep learning hardware.

Experiments:

1. Implementation of the backpropagation learning algorithm, 2. Implementation of gradient decent optimization algorithm.

Unit-4 - CNN for Perception	***12 Hour***
Image classification - LeNet, AlexNet, ResNet, and Inception architectures - Object detection - RCNN and YOLO architectures - Semantic and instance segmentation - Panoptic segmentation - Visual racking. Experiments: *1. CNN for object detection, 2. Image panoptic segmentation network.*	
Unit-5 - Planning and Control	***12 Hour***
Markov decision process - Deep reinforcement learning - POMDP - Deep-Q learning - Curriculum learning - Proximal policy optimization - Deep reinforcement learning in planning and control of autonomous ground robots and aerial robots: implementation in end-to-end decomposition manner. Experiments: *1. DRL for autonomous navigation of mobile robots in end-to-end manner, 2. DRL in planning and control of mobile robots.*	

Learning Resources	1. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2ndEdition, Springer, 2016.* 2. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, "DeepLearning", 1st Edition, MIT Press, 2016.*	3. *Simon Haykin, "Neural Networks and Learning Machines: AComprehensive Foundation", 3rd Edition, Pearson, 2011.* 4. *Timothy J Ross, "Fuzzy Logic with Engineering Applications", 3rdEdition, Wiley, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	-	*20%*	*10%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*30%*	-
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. *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. K. Sivanathan, SRMIST*

Course Code	21MHE462T	Course Name	ADVANCED DYNAMICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce representation of motion in different coordinate systems*
CLR-2:	*introduce energy-based approaches for deriving equations of motion of dynamical systems*
CLR-3:	*introduce behaviours of non-linear 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:	*derive the kinematics of dynamical systems in differential coordinate systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the D'Alembert's principle of virtual work and virtual power*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply Lagrangian's equation for deriving equations of motion of mechanical systems*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply Lagrangian's equation for deriving equations of motion of electromechanical systems*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*understand the non-linear dynamics*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Dynamical System	***9 Hour***
Principle and definition, Applications and failures, Motion description and kinematics in cartesian, cylindrical, polar, spherical and moving-coordinates	
Unit-2 - Constrained Motion and Generalized Coordinates	***9 Hour***
Static equilibrium: Virtual work, Relating kinematics and kinetics, D'Alembert's principle, Virtual power, differential algebraic constraint	
Unit-3 - Lagrangian Dynamics-I	***9 Hour***
Applying Lagrangian dynamics to mechanical systems	
Unit-4 - Lagrangian Dynamics-II	***9 Hour***
Applying Lagrangian dynamics to electromechanical systems and electrical systems	
Unit-5 – introduction to Non-Linear Dynamical Systems	***9 Hour***
Introduction to non-linear systems-Phase plane and vector fields, Chaos, and Limit cycle, Bifurcation	

Learning Resources	
	1. *Francis C Moon, Applied Dynamics: With Applications to Multibody and Mechatronic Systems, Wiley-VCH; 2nd edition (10September 2008), ISBN-10: 3527407510.* 2. *Soumitro Banerjee, Dynamics for Engineers, John Wiley & Sons, 2005*
	3. *Steven Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering, Westview Press; 2nd edition (29 July 2014), ISBN-10:0813349109* 4. *Robert L. Devaney, A First Course in Chaotic Dynamical Systems Theory and Experiment, CRC Press (1 January 2022), ISBN-10: 1032218525*

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*	-	-	-	-	*10%*	-
Level 2	*Understand*	*65%*	-	*50%*	-	*30%*	-
Level 3	*Apply*	*35%*	-	*50%*	-	*40%*	-
Level 4	*Analyze*	-	-	-	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr.D.Sathia Narayanan, Scientist F, Deep-sea technologies (DST), National Institute of OceanTechnology (NIOT), Ministry of Earth Sciences (MoES), Chennai, India – 600100*	1. *Dr Veera Ragavan Sampathkumar, Department ofRobotics and Mechatronics engineering, Monash University (Malaysia campus), Malaysia*	1. *Dr Madhavan Shanmugavel, SRMIST*
2. *Dr Affiani Machmudah, Research Center for Hydrodynamics, National Research and InnovationAgency, Indonesia, Jakarta Pusat 10340*	2. *Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	2. *Dr S.Sivanathan, SRMIST*

Course Code	21MHE463T	Course Name	SOFT ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*impart knowledge in the area of soft robotics and its controlling techniques*
CLR-2:	*understand about the materials and manufacturing techniques for soft robotics*
CLR-3:	*obtain the knowledge of different actuation techniques for soft robotics*
CLR-4:	*introduce the concepts of soft micro robot*
CLR-5:	*provide knowledge on various applications and challenges of soft robotics*

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 the concepts of soft robotics and sensing techniques*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the soft robotics materials and different manufacturing techniques*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the different soft robot actuation techniques*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*understand the basic concepts of soft micro robot*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*learn about the various applications and limitations of soft robots*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Soft Robotics	***9 Hour***
Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Structure, actuation, sensing and control	
Unit-2 - Materials and Manufacturing Techniques for Soft Robotics	***9 Hour***
Elastomers, Dielectric Elastomer-Fluid Materials, Liquid metal embedded elastomers, Hydrogels, Thermoplastics and textiles, Manufacturing Techniques – Additive Manufacturing, 3D printing, Shape deposition manufacturing	
Unit-3 - Actuation Techniques for Soft Robotics	***9 Hour***
Pneumatic actuation, Vacuum actuation, Cable driven actuation, Shape Memory alloy actuation, Electro active polymer actuation, Electro adhesive actuation	
Unit-4 - Soft Microrobot	***9 Hour***
Introduction, Materials for soft microrobot, Manufacturing techniques for Soft Micro robots (Lithography, Thin film manufacturing – Laser Micromachining) Actuation methods for Soft Micro robots, Application of soft micro robots	
Unit-5 - Applications and Challenges in Soft Robotics	***9 Hour***
Soft wearable robots for human augmentation and gait rehabilitation, soft actuators for robotics and biomimetic applications, Cable-driven systems for robotic rehabilitation, Limitations of soft robotics manufacturing and implementation.	

Learning Resources	
	1. *Gareth J. Monkman, Soft Robotics, Bentham Science Publishers, 2022.* 2. *Amir Jafari, Nafiseh Ebrahimi, Soft Robotics in Rehabilitation, Elsevier Science, 1st Edition, 2021.* 3. *Filippo Rossi, Luca Magagnin, Soft Robotics, Elsevier Science, volume 57,1st Edition, 2021.* 4. *Mohammad H. Elahinia, Shape Memory Alloy Actuators Design, Fabrication, and Experimental Evaluation, Wiley, 1st edition, 2016.* 5. *Antonio Riveiro, J. Paulo Davim, Juan Pou, Additive Manufacturing, Elsevier Science, 2021.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Senthil Kumar S, Assistant manager Grundfos pumps India Pvt Ltd*	1. *Prof. M. Bhaskaran, Assistant professor, KSR college of Technology*	1. *Dr.R.Gangadevi, Assistant Professor (Sr.G)*
2. *Mr. K. Gopinath, Intel Technology India PvtLimited, gopinath.k@intel.com*	2. *Prof. P.Ravichandran, Associate professor, Kongu Engineering college*	2. *Dr.S.Senthilraja, Assistant Professor*

Course Code	21MHE464T	Course Name	INTRODUCTION TO MARINE AND AERIAL ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce different types of marine-vessels and -robots, systems and configurations*
CLR-2:	*introduce the fundamentals of seakeeping and control of marine robotics*
CLR-3:	*introduce different types of aerial robots, systems and configurations*
CLR-4:	*introduce maneuvers and control in aerial robotics*
CLR-5:	*introduce motion control and collision avoidance in marine and aerial robotics*

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 the different types marine robots, systems and configurations*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*apply seakeeping concepts and control of marine robotics*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*understand different types aerial robots, systems and configurations*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply concepts of maneuver and control of aerial robotics*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*understand motion control and collision avoidance in marine and aerial robotics*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Marine Robotics	***9 Hour***
Types and classification of marine vessels, Systems & sub-systems, Hydrostatics, Buoyancy and Stability of marine vessels	
Unit-2 - Motion and Control of Marine Vessels	***9 Hour***
Introduction to Seakeeping, motion in water, and control of marine vessels	
Unit-3 - Aerial Robotics	***9 Hour***
Systems & configuration of aerial robots – Fixed wing and VTOL, Motion of AUV	
Unit-4 - Motion and Control of Aerial Robots	***9 Hour***
Maneuver and control of aerial robot at constant altitude. Introduction to motion in 3d space	
Unit-5 - Motion Planning and Collision Avoidance in Marine & Aerial Robotics	***9 Hour***
Mission requirements and motion planning techniques, Collision avoidance	

Learning Resources

1. *Alexander schlaelfer and ole blaurock, Robotic sailing, Proceedings of the 4th International sailing conference, Springer, 2011*
2. *Sabiha A. wadoo,pushkin kachroo, Autonomous underwater vehicles, modelling, control design and Simulation, CRC press, 2011*
3. *Reg Austin, Unmanned Aircraft Systems, Wiley & Sons (2010)*
4. *Paul Gerin Fahlstrom, and Thomas James Gleson, Introduction to UAV systems, John Wiley (2012)*
5. *Gianluca Antonelli, Underwater robotics, Springer, 2014*
6. *Richard A Geyer, "Submersibles and their use in oceanography and ocean engineering", Elsevier, 1997*
7. *Ferial L hawry, The ocean engineering handbook, CRC press,2000*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	-	-	-	*10%*	-
Level 2	*Understand*	*70%*	-	*70%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*65%*	-
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.D.Sathia Narayanan, Scientist F, Deep-sea technologies (DST), National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences (MoES), Chennai, India – 600100*	1. *Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	1. *Dr Madhavan Shanmugavel, SRMIST*
2. *Dr Affiani Machmudah, Research Center for Hydrodynamics, National Research and Innovation Agency, Indonesia, Jakarta Pusat 10340*	2. *Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu*	2. *Dr Ranjith Pillai, SRMIST*

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