ACADEMIC CURRICULA

Professional Elective Courses

MECHATRONICS ENGINEERING

Regulations - 2018

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18MHE401T	Course Name	ELEMENTS OF MECHATRONICS SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the key elements of mechatronics system and the design issues*
CLR-2 :	*Identify the different types of sensors used in mechatronics system*
CLR-3 :	*Identify the different types of actuators used in mechatronics system*
CLR-4 :	*Identify the different types of controllers used in mechatronics system*
CLR-5 :	*Identify the mechatronics system applied for different applications*
CLR-6 :	*Utilize the elements of mechatronics systemsfor different applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Analyze the various elements of mechatronics system*	*1*	*85*	*80*	*H*	*L*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	*M*	-	-
CLO-2 :	*Analyze the different types of sensor for developing a mechatronics system*	*2*	*85*	*80*	*H*	*H*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	-	-	-
CLO-3 :	*Analyze the different types of actuators for developing a mechatronics system*	*2*	*85*	*80*	*H*	*H*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	-	-	-
CLO-4 :	*Analyze the different types of controllers for developing a mechatronics system*	*2*	*85*	*80*	*H*	*H*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	-	-	-
CLO-5 :	*Apply the mechatronics elements in to various applications*	*2*	*85*	*80*	*H*	*H*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	-	-	-
CLO-6 :	*Apply the sensors and actuators for developing a mechatronics system*	*2*	*85*	*80*	*H*	*H*	-	*H*	*M*	-	*L*	*L*	*M*	-	-	-	-	-	-

		Introduction to Mechatronics Systems	Sensors	Actuation System	Controllers	Applications of Mechatronics Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to mechatronics system*	*Sensor characteristics*	*Introduction to electrical ,mechanical, hydraulic and pneumatic actuation system*	*Proportional, Integral controller*	*Car park barriers using PLC.*
	SLO-2	*Definition of mechatronics: Concurrent and sequential integration*	*Signal conditioning system*	*Solid state switches*	*Derivative and PID controller*	*Bar code reader*
S-2	SLO-1	*The Design process*	*Resistive sensors*	*Construction and operation of solenoids*	*Example: Boiler control using PID*	*Coin counting machine*
	SLO-2	*Mechatronics design elements*	*Types and working principle*	*Relay Construction, working principle, Types and applications.*	*Introduction to Micro controller*	*Conveyor based material handling system*
S-3	SLO-1	*Measurement system*	*Capacitive sensors*	*DC motor: Construction and principle of operation*	*Architecture of M68HC11 microcontroller*	*Computer controlled CNC drilling machine*
	SLO-2	*Actuation system*	*Types and working principle*	*AC motor: construction and principle of operation*	*Architecture of ATMEGA328 microcontroller*	*Computer controlled CNC drilling machine*
S-4	SLO-1	*Control system*	*Inductive transducers*	*Stepper motors: Construction and principle of operation*	*Signal processing, Multiplexer and Demultiplexer*	*Electronic car engine management system*
	SLO-2	*Control system*	*Types and working principle*	*Types of stepper motor*	*Dataacquisition system*	*Solenoid operated fuel injector: construction*

						and operation
S-5	SLO-1	Introduction to microprocessor based controllers	Temperature sensors	Servo motors: Construction, principle of operation	Types: A/D converters	Electronic control of steering system
	SLO-2	Intelligent control	Types and working principle	Types of servo motor	Types: D/A converters	Autonomous guided vehicle (AGV)
S-6	SLO-1	System integration	Pressure sensors	Construction and operation of Synchronous motor	Basic structure, Programming units and Memory ofProgrammable logic controller	Automatic vehicle transmission system
	SLO-2	Integrated design issues in mechatronics	Types and working principle	Construction and operation of BLDC motor	Input and Output Modules, Mnemonics for programming	Wind screen wiper using stepper motor control
S-7	SLO-1	Hardware in loop simulation	Nano sensor Parameters and characteristics. Necessity of Nano scale measurements	Construction and operation of PMDC motor	Timers	Pneumatic controlled three axis Pick and place robot
	SLO-2	Shaft speed control	Magneto resistance Nano sensor, Hall effect Nano sensor	Pressure control valve	Counters and Shift Registers	Obstacle avoidance robot
S-8	SLO-1	Water level controller	NEMS accelerometer	Rotary actuators and cylinders	Latching and Internal relays	Self-balancing robot
	SLO-2	Open loop and closed loop temperature control system	Silicon nanowire accelerometer	Hydraulic and pneumatic systems with example	Master relay and Jump Controls	Actuation of robotic gripper using SMA wire
S-9	SLO-1	Washing machine control	Optical displacement Nano sensor, Magneto motive displacement Nano sensor	Mechanical actuation system :Types of motion	Programming the PLC using Ladder diagram for Simpleapplications	Nano mechanical cantilever based manipulation for sensing and imaging.
	SLO-2	Digital camera control	Piezoresistive and Piezoelectric displacement Nano sensor	Kinematic chains, Cams actuation with example, Gear trains with example	Programming the PLC using Ladder diagram for Simpleapplications	Swam of self-organized nano Robots.

Learning Resources	1. Bolton, W., "Mechatronics", Addison Wesley, 2nd edition, New Delhi, 1999. 2. Vinod Kumar Khanna., "Nanosensors: Physical, Chemical and Biological", CRC press, 2012 3. Gabor L. Hornyak., John J. Moore., H.F. Tibbals, JoydeepDutta., "Fundamentals of Nanotechnology", CRC Press, 2009.	4. ConstantinosMavroidis, Antoine Ferreira., "Nanorobotics: Current Approaches and Techniques", Springer 2013. 5. Bradley.D.A, Dawson.DBurdN.C.and Loader A.J, "Mechatronics", Chapman and Hall Publications,New York, 1993. 6. Rohner.P, "Automation with Programmable Logic Controllers", Macmillan / McGraw Hill, New York,1996. 7. Jacob Fraden, "Handbook of Modern Sensors Physics, Designs, and Applications", Third Edition,Springer-Verlag New York, 2004.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE402T	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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 various architecture of industrial robot*
CLR-2 :	*Introduce the vector transformation applied to robotics*
CLR-3 :	*Introduce the forward and inverse kinematics applied to serial manipulator robot*
CLR-4 :	*Emphasize on the various actuators and transmission element used in robot. Also to define various control strategy used in manipulator robotics*
CLR-5 :	*Introduce the formulation of various trajectories*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Understand the architecture and basic technical terms used in robotics*	*2*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-2 :	*Learn the application of vector transformation in robotics*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	-	-
CLO-3 :	*Learn to compute the forward and inverse kinematics model for various configuration of serial manipulator*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*H*	-	-	*H*	*H*	-	-
CLO-4 :	*Understand the various actuators and transmission elements used in robot. Also will learn the various control and trajectory planning algorithm*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-
CLO-5 :	*Understand the trajectory planning techniques and various industrial workcell*	*2*	*80*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	*M*	-	-	*H*	*H*	-	-

		Introduction to Robotics	Transformations	Manipulator Kinematics	Introduction to sensors and actuators in robotics	Trajectory planning and work cell
Duration (hour)		7	12	8	9	9
S-1	SLO-1	*Definition of Robot, Laws of Robotics,*	*Description of point in space*	*Introduction to Manipulator Kinematics*	*Basic actuators and transmission elements*	*Introduction-Trajectory Planning.*
	SLO-2	*Basic terminologies used in robotics*	*Description of body in space*	*Forward Kinematics*	*Mathematical model of DC motor*	*Approach and importance of trajectory planning*
S-2	SLO-1	*Classification based on application*	*Review of Vectors*	*Forward Kinematics of RR planar manipulator- geometric approach*	*Harmonic Drives*	*Joint space and Cartesian space planning*
	SLO-2	*Classification based on work volume*	*Vector representation of points and bodies*	*Numerical*	*Computation of reduction ratio of harmonic drive and its advantage*	*Difference with an example*
S-3	SLO-1	*Definition – precision, repeatability and accuracy*	*Translation- Numerical*	*DH formulation*	*Force sensor and its uses*	*Cubic Polynomial trajectory planning*
	SLO-2	*Co-ordinate systems used in robotics, Degree of freedom with examples*	*Rotation-Numerical*	*Difference between modified and standard DH convention with example of RR planar manipulator*	*Maltese cross configuration*	*Problem on Cubic Polynomial trajectory planning*
S-4	SLO-1	*Links and various joints in robotics*	*Representing Rotation- Rotation Matrix*	*Forward kinematics of 3R spatial articulated arm*	*Importance of force control using force sensor*	*Case study on trajectory planning for manipulator robot*
	SLO-2	*Anatomy of Robot*	*Properties of Rotation matrix*	*Derivation of final DH matrix for 3R spatial articulated arm*	*Case study – Application of force sensor*	*Case study on trajectory planning for manipulator robot*
S-5	SLO-1	*RPY wrist*	*Numerical on rotation matrix*	*Forward kinematics of RPY wrist*	*Tactile sensor*	*Robot work cell layout*
	SLO-2	*Configuration space and operational space*	*Numerical on rotation matrix*	*Derivation of final DH matrix for RPY wrist*	*Various Tactile sensors- principle and working*	*Classification of robot work cell*

S-6	SLO-1	Robot data sheet interpretation	Representing Rotation- Euler angles	Forward kinematics of 4 DOF SCARA robot	Slip Sensor	Multiple robot
	SLO-2	Important terms and finding in datasheet of manufacturer	Numerical	Derivation of final DH matrix for 4 DOF SCARA robot	Slip Sensor	Work cell control
S-7	SLO-1	Robot End effector	Representing Rotation- Equivalent axis representation	Introduction to Inverse kinematics	Application of tactile and slip sensor	Safety monitoring
	SLO-2	Types of gripper	Numerical	Inverse Kinematics of RR planar manipulator- Geometric approach	Case Study	Error detection and recovery
S-8	SLO-1		Difference between Current axis and fixed axis representation	Issues in Inverse Kinematics	Vision system for robot	Robot Cycle time analysis
	SLO-2		Numerical	Issues in Inverse Kinematics	Vision architecture block diagram	Economic analysis of robot
S-9	SLO-1		Homogenous Transformation		Case study on Vision based control	Criteria for selection of robot work cell
	SLO-2		Numerical		Case study on Vision based control	Case Study- Selection of robot based on application
S-10	SLO-1		Operators and Mapping Concept			
	SLO-2		Case Study- Numerical			
S-11	SLO-1		Compound Transformation			
	SLO-2		Case Study			
S-12	SLO-1		Case study of transformations in robotics			
	SLO-2		Case study of transformations in robotics			

Learning Resources	1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012. 2. John J. Craig, “Introduction to Robotics”, Addison Wesley, ISE 2008. 2. 3. Deb S.R., “Robotics Technology and Flexible Automation”, Tata McGraw - Hill Publishing Company Limited, 2012...	3. ArthorCritchlow, “Introduction to Robotics”, Macmillan, 2009. 4. Mohsen Shahinpoor, “A Robot Engineering Text Book”, Harper and Row, 2004 5. 6. Mittal R.K., and Nagrath I.J., “Robotics and Control”, 1st edition, Tata McGraw Hill, 2007.

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply / Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate / Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com	1. Dr. G. Murali, SRMIST
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu	2. Ranjith Pillai R, SRMIST

Course Code	18MHE403T	Course Name	INDUSTRIAL INSTRUMENTATION AND CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain the knowledge of industrial automation*
CLR-2 :	*Identify the need for process control*
CLR-3 :	*Build the various concepts of PID tuning*
CLR-4 :	*Utilize the control algorithm for actuators*
CLR-5 :	*Gain knowledge of programmable logic controllers*
CLR-6 :	*Introduce the knowledge of distributed control systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Knowledge of industrial automation*	*2*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-2 :	*Knowledge of process control*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-3 :	*Design of PID based control tuning methods*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-4 :	*Application of control algorithm for actuators*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-5 :	*knowledge of programmable logic controllers*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-6 :	*Interpret the knowledge of distributed control systems*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	-	-	-	-	-	-	*H*	*H*	*H*	*H*

		Industrial Automation	Process Control	Controlling of Actuators	Programmable Logic Controllers	Distributed Control Systems
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Evolution of instrumentation and control.*	*Introduction of Process control*	*Need of Machine tools control*	*Introduction of sequence Control*	*Introduction to Distributed Control Systems*
	SLO-2	*Need of instrumentation and control.*	*Need of Process control*	*Need of Machine tools control*	*Need of sequence Control*	*Need of Distributed Control Systems*
S-2	SLO-1	*Need of automation in industry*	*Basics of P I D control*	*Need of CNC Machines*	*Need of Programmable Logic Controllers*	*Concept of Distributed Control Systems*
	SLO-2	*Role of automation in industry*	*Implementation of PID controllers*	*Components of CNC Machines*	*Need of Programmable Logic Controllers*	*Components of Distributed Control Systems*
S-3	SLO-1	*Components of industrial automation systems*	*Need for controller tuning*	*Analysis of a control loop*	*Concepts of Relay Ladder Logic*	*Functions of DCS*
	SLO-2	*Architecture of industrial automation systems*	*Steps in controller tuning*	*Analysis of a control loop*	*Need of Relay Ladder Logic*	*Advantages and limitations of DCS*
S-4	SLO-1	*Need for sensors*	*Need of digital controllers*	*Adjustable field drives*	*Scan cycle*	*DCS as an automation tool*
	SLO-2	*Need for measurement systems*	*Significance of digital controllers*	*DC motor drive*	*RLL Syntax*	*Enterprise Resource Planning by DCS*
S-5	SLO-1	*Pressure measurement*	*Principles of predictive control*	*Need of variable frequency control*	*Analog control using PLC*	*Schematic block diagram of DCS*
	SLO-2	*Force measurement*	*Principles of predictive control*	*Variable frequency control of induction motor drive*	*Analog control using PLC*	*Schematic block diagram of DCS*
S-6	SLO-1	*Need of temperature measurement*	*Control of systems with inverse response*	*Need of closed loop control*	*Advanced RLL programming*	*Need of date acquisition*
	SLO-2	*Thermocouple and Thermistor*	*Control of systems with inverse response*	*Closed loop synchronous motor drive*	*Advanced RLL programming*	*Concepts of data acquisition*
S-7	SLO-1	*Displacement measurement*	*Special control structures*	*Need of proportional valve in fluid power systems*	*PLC interfacing to SCADA/DCS using Communications links*	*Specifications involved in DCS*

	SLO-2	*Speed measurement*	*Concepts of cascade control*	*Implementation of proportional valve in fluid power systems*	*PLC interfacing to SCADA/DCS using Communications links*	*Specifications involved in DCS*
S-8	SLO-1	*Measurement of level*	*Introduction of automation tools*	*Need of proportional valve in fluid power systems*	*Need for industrial Ethernet*	*Latest trends in DCS*
	SLO-2	*Measurement of humidity and pH*	*PLC and DCS*	*Implementation of proportional valve in fluid power systems*	*Implementation of industrial Ethernet*	*Latest developments in DCS*
S-9	SLO-1	*Need for Signal Conditioning*	*SCADA*	*PID based pneumatic controllers for positioning*	*Advanced applications of PLC*	*SCADA specifications for different real time applications*
	SLO-2	*Need for Signal processing*	*Hybrid DCS/PLC*	*PID based pneumatic controllers for positioning*	*Advanced applications of PLC*	*SCADA specifications for different real time applications*

Learning Resources	1. *William .C. Dunn., "Fundamentals of industrial instrumentation and process control", McGraw-Hill Publications, 2005.* 2. *Patranabis. D., "Principles of industrial instrumentation", Tata McGraw-Hill, 3rd edition, 2010.* 3. *Bolton. W., "Programmable logic controllers", Newnes Publications, 4th edition, 2006.*	4. *Groover. M.P., "Automation, production systems and computer integrated manufacturing", 3rd edition, Prentice Hall of India, 2007.* 5. *Stuart A Boyer., "SCADA supervisory control and data acquisition", International society of automation (ISA) Publications, 4th edition, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K.P.Srinivasan, Visteon Automotive Electronics Limited, Chennai, psriniv1@visteon.com	*1. Dr. B. Mohan, Anna University, Chennai, mohan@mitindia.edu*	*1. Dr. T. Muthuramalingam, SRMIST*
2. Mr. S. EllanChezhiyan, Keyence Microscope Limited, Chennai, ellanchezhian@gmail.com	*2. Dr. D. Saravanakumar, Vellore Institute of Technology, Chennai, saravanakumar.d@vit.ac.in.*	*2. Dr. M. Mohamed Rabik, SRMIST*

Course Code	18MHE404T	Course Name	INDUSTRIAL AUTOMATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify potential areas for automation and justify need for automation.*
CLR-2 :	*Select suitable major control components required to automate a process.*
CLR-3 :	*Translate and simulate a real time activity using modern tools*
CLR-4 :	*Discuss the benefits of automation.*
CLR-5 :	*Identify the suitable automation hardware for the given application.*
CLR-6 :	*Model and simulate tool for the given manufacturing operation.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify potential areas for automation and justify need of it.*	*2*	*75*	*70*	*H*	*M*	*M*	*H*	*M*	*L*	*M*	*L*	*M*	*M*	*-*	*H*	*H*	*H*	*H*
CLO-2 :	*Analyze suitable major control components required to automate a process.*	*3*	*75*	*70*	*H*	*M*	*M*	*H*	*M*	*L*	*M*	*-*	*M*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-3 :	*Able to Translate and simulate a real time activity using modern tools*	*3*	*75*	*70*	*H*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*-*	*-*	*-*
CLO-4 :	*Analyze discuss the benefits of automation.*	*3*	*75*	*70*	*H*	*M*	*M*	*-*	*L*	*L*	*M*	*L*	*-*	*M*	*L*	*H*	*H*	*H*	*H*
CLO-5 :	*Analyze suitable automation hardware for the given application.*	*3*	*75*	*70*	*H*	*M*	*M*	*H*	*L*	*-*	*M*	*L*	*M*	*M*	*L*	*H*	*-*	*-*	*-*
CLO-6 :	*Apply Model and simulate tool for the given manufacturing operation.*	*3*	*75*	*70*	*H*	*M*	*-*	*H*	*M*	*L*	*M*	*L*	*M*	*M*	*L*	*H*	*H*	*H*	*H*

Duration (hour)		Automation in production system	Automated manufacturing systems	Industrial control systems.	Computer based industrial control	Modeling and simulation for plant automation:
		9	9	9	9	9
S-1	SLO-1	*Automation in production system,*	*Automated manufacturing systems:*	*Industrial control systems.*	*Computer based industrial control*	*Modeling and simulation for plant automation:*
	SLO-2	*principles and strategies of automation,*	*Components, classification and*	*Process industries*	*Need for the system*	*Introduction and process.*
S-2	SLO-1	*Basic elements of an automated system.*	*overview of manufacturing systems,*	*Discrete manufacturing industries.*	*Automatic process control.*	*Need for system modeling.*
	SLO-2	*Functions of automation*	*Manufacturing cells.*	*Process industries versus discrete manufacturing industries.*	*Building blocks of automation systems:*	*Building model of a plant.*
S-3	SLO-1	*levels of automations*	*Group technology*	*Control systems*	*LAN*	*Cement plant*
	SLO-2	*Advanced automation*	*Cellular manufacturing.*	*Basic elements of control system*	*Interface.*	*Thermal plant*
S-4	SLO-1	*flow lines*	*Flexible manufacturing system*	*Continuous control*	*Computer Networks*	*water treatment plant*
	SLO-2	*transfer mechanisms*	*planning for FMS*	*Discrete control.*	*Topology.*	*Steel plant*
S-5	SLO-1	*fundamentals of transfer lines*	*Implementation of FMS*	*Continuous versus discrete control.*	*Analog I/O Modules,*	*Modern tools*
	SLO-2	*Material handling systems: Introduction*	*Quality control systems,*	*Regulatory control*	*Digital I/O Modules,*	*Future perspective.*
S-6	SLO-1	*principles and design considerations*	*traditional and modern quality control methods*	*Feed forward control.*	*SCADA systems*	*Industrial control applications: Cement plant*
	SLO-2	*Material transport systems – out bound*	*SPC tools.*	*Automated control*	*Real-time user interface.*	*Design and implementation*
S-7	SLO-1	*Introduction, conveyors.*	*inspection principles*	*Adaptive control*	*Distributed control system,*	*thermal plant*
	SLO-2	*Industrial robots*	*practices*	*Definition, Types*	*Functional requirements.*	*Design and implementation*
S-8	SLO-1	*Automated guided vehicles.*	*Inspection technologies.*	*Comparisons*	*Elements of DCS*	*Industrial control applications: Water treatment*

						plant
	SLO-2	*Storage systems:*	*overview of automatic identification methods*	*online strategies*	*Configurations of DCS.*	*Design and implementation*
S-9	SLO-1	*Automatic storage and retrieval systems.*	*Barcode readers*	*Computer process*	*Popular distributed control systems.*	*Industrial control applications: steel plant*
	SLO-2	*Realtime Application*	*Machine vision systems.*	*Forms of computer process*	*Realtime Application*	*Design and implementation*

Learning Resources	1. *P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, 5th edition, 2009.* 2. *Krishna Kant, "Computer Based Process Control", Prentice Hall of India, 2nd edition, 2010.* 3. *Tiess Chiu Chang and Richard A. Wysk, "An Introduction to Automated Process Planning Systems", Prentice Hall of India, 1985.*	4. *Viswanandham, "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India, 1st edition, 2009.* 5. *S.K.Singh, "Computer Aided Process Control", Prentice Hall of India, 1st edition, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Sivaramakrishnan, MIT, Anna University, Chennai*	*1. Dr. B K Vinayagam, SRMIST*
2. Mr. ElayarajSivaraj, Tesla,California, elayaraj@hotmail.com	*Dr. R.ArockiaRajan, IIT-Madras, Chennai*	*2. Mr. S,Vigneshwaran, SRMIST*

Course Code	18MHE405T	Course Name	MANUFACTURING INFORMATION SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the Concepts of information*
CLR-2 :	*Identify the information generated in manufacturing industry*
CLR-3 :	*Understandthe concepts of database systems in manufacturing industry*
CLR-4 :	*Understand the database design and architecture*
CLR-5 :	*Comprehend the computerized manufacturing information systems*
CLR-6 :	*Understand computerized production planning and scheduling systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Identify the various concepts of information with respect to products and processes in manufacturing industry*	2	90	85	H	L	-	M	-	-	-	-	L	-	-	-	-	L	L
CLO-2 :	*Identify the orderly arrangement of information flow in the manufacturing processes*	2	90	85	H	H	-	M	-	-	-	-	L	-	-	-	-	L	L
CLO-3 :	*Compare the different types of database systems and utilize the most appropriate one for a given manufacturing industry*	2	90	85	H	M	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-4 :	*Identify the suitable database design and architecture for a given manufacturing industry*	2	90	85	H	M	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-5 :	*Select the rational computerized manufacturing system for the products*	2	90	85	H	H	-	H	-	-	-	-	L	-	-	-	-	L	L
CLO-6 :	*Chose the rational computer based production management system for production data control, customer order servicing and plant control*	2	90	85	H	H	-	H	-	-	-	-	L	-	-	-	-	L	L

Duration (hour)		INTRODUCTION	DATA PROCESSING	DATA HANDLING	DATA FORM	NEED OF COMPUTER IN MANUFACTURING
		9	9	9	9	9
S-1	SLO-1	*Need for manufacturing*	*Introduction to data base system*	*Introduction to relational database.*	*Basic QBE and multiple relations*	*Parts oriented production information system concept*
	SLO-2	*Need for manufacturing*	*Need for database system*	*Introduction to relational database.*	*Basic QBE and multiple relations*	*Parts oriented production information system concept*
S-2	SLO-1	*Macroscopic view of manufacturing organization*	*Need for database system*	*Integrity constraints over relations*	*Aggregates, condition box, data base design: Schema refinement*	*Parts oriented production information system structure*
	SLO-2	*Macroscopic view of manufacturing organization*	*Benefits of database approach*	*Integrity constraints over relations*	*Aggregates, condition box, data base design: Schema refinement*	*Parts oriented production information system structure*
S-3	SLO-1	*Principal properties of manufacturing information: MRP I*	*Data and data models*	*Enforcing integrity constraint*	*Functional dependencies and reasoning*	*Computerized production scheduling*
	SLO-2	*Principal properties of manufacturing information: MRP II*	*Data and data models*	*Enforcing integrity constraint*	*Functional dependencies and reasoning*	*Computerized production scheduling*
S-4	SLO-1	*Principal properties of manufacturing information: SFC*	*Entity and relationship diagram*	*Querying relational data*	*Trivial and non-trivial dependencies.*	*Online production control system*
	SLO-2	*Principal properties of manufacturing information: MPS*	*Diagram, database design with E/R model*	*Logical database design.*	*Trivial and non-trivial dependencies.*	*Online production control system*

S-5	SLO-1	*Information principles of manufacturing*	*Data independence and stored fields*	*Translating ER model to relational model.*	*Closure of a set of dependencies and attributes.*	*Computer based production management system: Engineering and production data control*
	SLO-2	*Information principles of manufacturing*	*Records and files.*	*Translating ER model to relational model*	*Closure of a set of dependencies and attributes.*	*Computer based production management system: Engineering and production data control*
S-6	SLO-1	*Measurement of manufacturing information*	*Three levels of architecture: External*	*Relational algebra and queries*	*Normal forms and normalization: First form*	*Computer based production management system: Customer order servicing*
	SLO-2	*Information physics, Communication approach*	*Three levels of architecture: Internal and conceptual.*	*Syntax and semantics*	*Normal forms and normalization: Second form*	*Computer based production management system: Customer order servicing*
S-7	SLO-1	*Synthesis of manufacturing information*	*Mappings*	*Form of basic SQL query*	*Normal forms and normalization: Third form*	*Computer based production management system: Forecasting*
	SLO-2	*Information intensity and value matrices*	*DBMS functions and components*	*Form of basic SQL query*	*Normal forms and normalization: Third normal form*	*Computer based production management system: Plant maintenance and control*
S-8	SLO-1	*Dual nature of manufacturing information*	*Data Communication*	*Union, intersect and except*	*Multi valued dependency and fourth normal form*	*Computerized manufacturing information system, case study*
	SLO-2	*Performance maximization rules*	*Data Communication*	*Nested queries*	*Multi valued dependency and fourth normal form*	*Computerized manufacturing information system, case study*
S-9	SLO-1	*Materialization of manufacturing information*	*Distributed processing*	*Aggregate queries and null values*	*Join dependencies and fifth normal form*	*Computerized manufacturing information system, case study*
	SLO-2	*Materialization of manufacturing information*	*Distributed processing*	*Triggers and active databases*	*Join dependencies and fifth normal form*	*Computerized manufacturing information system, case study*

Learning Resources	1. *Date.C.J., "An Introduction to Database Systems", Addison Wesley, 8th edition 2003.* 2. *Raghu Ramakrishnan and Johannes Gehrke, "Data Base Management Systems", McGraw- Hill Higher Education, 3rd edition 2002.* 3. *Luca G.Sartori, "Manufacturing Information Systems", Addison-Wesley Publishing Company, 1988. Reference Books/Other Reading Materials*	4. *FranjoCecelja, "Manufacturing Information and Data systems – Analysis, Design and Practice", ISBN: 978-1-85718-031-2, Elsevier, 2002.* 5. *John A. Schey, Introduction to manufacturing processes, 3rd ed., McGraw-Hill, 2000* 6. *Zude Zhou, Shane (Shengquan) XieDejun Chen, "Fundamentals of Digital Manufacturing Science", ISBN 978-0-85729-563-7, Springer-Verlag London Limited, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. A. Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*Dr.R.Sivaramakrishnan, MIT, Anna University, Chennai*	*1. Dr. B K Vinayagam, SRMIST*
2. Mr. ElayarajSivaraj, Tesla,California, elayaraj@hotmail.com	*Dr. R.ArockiaRajan, IIT-Madras, Chennai*	*2. Mr. J.Arivarasan, SRMIST*

Course Code	18MHE406T	Course Name	INDUSTRIAL ELECTRONICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	18MHC103T, 18MHC204T	Co-requisite Course	Nil	Progressive Courses	Nil
Course Offering Department	Mechatronics Engineering	Data Book/Codes/Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify different Regulators and utilize them in different Regulated Power supply circuits
CLR-2 :	Recognizes the concept of heating and welding.
CLR-3 :	Identify working principle of different speed control methods for DC and AC motor.
CLR-4 :	Apply Power semiconductor switching devices concept in industrial applications.
CLR-5 :	Identify the principle of chopper to drive servo motors
CLR-6 :	Gain knowledge on regulators for regulated power supplies, Power Semiconductor devices for industrial applications, operate DC and AC drives using converters.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Analyze various regulators used in Power supplies	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-
CLO-2 :	Interpret the working principle of heating and welding in order to apply the advanced controls to improve their knowledge in understanding the concept of heating and welding.	3	75	70	H	M	M	H	H	-	M	L	H	M	-	H	-	-	-
CLO-3 :	Explore themselves familiar with functions of several industrial motor controls.	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-
CLO-4 :	Operate various industrial appliances using Power semiconductor switching devices	3	75	70	H	-	L	H	M	-	H	L	M	M	-	H	-	-	-
CLO-5 :	Operate UPS and servo motors using Choppers	3	75	70	H	-	L	H	M	-	M	L	M	M	-	H	-	-	-
CLO-6 :	Identify power semiconductor devices, regulators, choppers, heating and welding, speed control methods for operating electric drives.	3	75	70	H	L	M	H	M	-	L	L	M	M	-	H	-	-	-

		Introduction to Regulators and Power Supplies	Heating and Welding Control	Industrial Motor Control	Industrial Application of Power Switching Devices	AC Power Conditioner
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Concept of regulation, block diagram of a regulated power supply	Electronic control of heating: Introduction, Types	Method of controlling speed of DC motor	Principle of operation of automatic battery charger using SCR	Power supply noise
	SLO-2	Significance of regulated power supply.	Electronic control of heating: Resistance heating principle, Induction heating	Basic control circuit: DC motor control	Working of automatic battery charger using SCR	Different forms of noise.
S-2	SLO-1	Performance parameters: Major specifications of a regulated power supply, line and load regulation, output ripple and transients.	Induction heating: Principle of operation	Speed control of DC motors: Types	Principle of operation of emergency light using SCR.	Servo system: Fundamentals of Servo motor
	SLO-2	Concepts of fold back limiting, short circuit and overload protection.	Electronic control of heating: effects of supply frequency and source voltage, choice of frequency,	Speed control of small DC motors-operating principle	Working of emergency light using SCR.	Servo system: Principle of Servo motor
S-3	SLO-1	Principle of series regulators	Electronic control of heating: advantages and applications	Solid state motor control: Speed control of DC shunt motor using thyristor technology.	Principle of operation of Time delay relay circuit	Principle of buck-boost control of a servo controlled voltage stabilizer

	SLO-2	*Types of Series regulators*	*High frequency induction heating: Fundamentals, Operation*	*Speed control of DC shunt motor using thyristor technology.*	*Working of Time delay relay circuit*	*Working of buck-boost control of a servo controlled voltage stabilizer*
S-4	SLO-1	*Principles of shunt regulators: Types*	*High frequency induction heating: Types*	*PLL control of a DC motor control*	*Automatic temperature control circuit.*	*Servo-controlled voltage stabilizer, Constructional features*
	SLO-2	*Types of shunt regulators*	*Electronic heaters employed for induction heating.*	*Over-voltage and Over load protection of DC motors.*	*Automatic temperature control circuit: types.*	*Servo-controlled voltage stabilizer: Principle of operation*
S-5	SLO-1	*Three terminal voltage regulator ICs: Positive, negative and variable applications.*	*Operation of Electronic heaters employed for induction heating.*	*AC motor control: Methods*	*Battery operated inverter circuit using power transistor*	*Ferro-resonant AC regulator-Synchro: Constructional features*
	SLO-2	*Three terminal voltage regulator ICs: negative and variable applications.*	*Thyristorised supplies used in induction furnaces*	*Speed control of three phase induction motor*	*Illumination control using SCR*	*Ferro-resonant AC regulator-Synchro: Principle of operation*
S-6	SLO-1	*Switched Mode Power Supply: Basic working principles*	*Dielectric heating: Working principle*	*Speed control of single phase induction motor.*	*Illumination control using DIAC.*	*UPS- Introduction, Types*
	SLO-2	*Switched Mode Power Supply: applications, advantages and disadvantages.*	*Dielectric heating: Advantages and disadvantages, Applications*	*Speed control of single phase induction motor.*	*Illumination control using TRIAC.*	*UPS - Principle of operation Online UPS*
S-7	SLO-1	*Concept of floating and grounded power supplies*	*Electronic control of welding, electric welding*	*TRIAC as a starter for single phase induction motors and universal series motor.*	*Electronic timers: Introduction*	*UPS - Principle of operation Offline UPS*
	SLO-2	*Concept of floating and grounded power supplies: interconnections to obtain multiple output supplies.*	*Classification of resistance welding.*	*Operation of TRIAC as a starter for single phase induction motors and universal series motor.*	*Advantages of Electronic timers*	*Advantages and Applications of UPS, Comparison of different types of UPS*
S-8	SLO-1	*Switch Mode Power Supply: Fly back converter.*	*Control circuit for resistance welding*	*Applications of AC line voltage controllers circuit.*	*Electronic timers: Sequential timer.*	*Principle of operation of choppers: Types*
	SLO-2	*Switch Mode Power Supply: forward/buck converter*	*Operation of Control circuit for resistance welding*	*Zero voltage switching circuit.*	*Digital timer*	*Principle of operation of step up chopper.*
S-9	SLO-1	*Switch Mode Power Supply: Boost converter and buck-boost converter*	*AC resistance heating.*	*Synchronous tap changer circuit.*	*Electronic time delay circuits.*	*Principle of operation of step down chopper.*
	SLO-2	*Switch Mode Power Supply: cuk converter.*	*Operation and circuit of AC resistance heating*	*AC power control of a lamp dimmer circuit.*	*Electronic time delay circuits: Advantages, Applications.*	*Principle of operation of reversible chopper.*

Learning Resources	1. *S. Bhattacharya, S. Chatterjee, "Industrial Electronics And Control", Tata McGraw Hill, 2006.* 2. *Dubey, G.K., Doradia. S.R., Joshi.A. andSingh.R.M., "Thyristorised Power Controllers", Wiley Eastern Limited, 2008.* 3. *Biswanath Paul, "Industrial Electronics and Control", Prentice Hall India publisher , 2004.*	4. *Chitode .J.S, "Industrial Electronics", Technical Publications, 2009.* 5. *G. K. Mithal, "Industrial and Power Electronics", Khanna Publishers, Delhi, 2000.* 6. *M. H. Rashid, "Power Electronics Circuits, Devices and Application", Prentice Hall of India, 3rdedition, 2004.* 7. *Terry Baltelt, "Industrial electronics, devices, systems and applications", Delmar publishers, 2006.* 8. *Stephan L.Herman, Walter N.Alerich, "Industrial Motor Control", 4th edition, Delmar publishers, 2010.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.S.AnandaKumar, Deputy Chief Engineer, Control & Instrumentation, NLC India Ltd.,sith.anandkumar@gmail.com	*1. Dr.M.Jagadeeshkumar,SriSaiRam Institute of Technology, jagadeeshkumar.eee@sairamit.edu.in*	*1.Dr.M.SanthoshRani,SRMIST*
2. Mrs.T.Priya,Sr.Design Engineer, Electrical & Instrumentation, KavinEngg and Services Pvt. Ltd, priya@kavinengg.com	*2. Dr.S.S. Dash,Government College of Engineering Kednhhar,Odisha, munu_dash_2k@yahoo.com*	*2. Mrs.V.Krithika, SRMIST*

Course Code	18MHE407T	Course Name	GEOMETRIC MODELLING	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain the knowledge in fundamentals of Graphics and transformations.*
CLR-2 :	*Impart the Knowledge in modeling of CAD system.*
CLR-3 :	*Learn the various algorithm used in geometric modelling*
CLR-4 :	*Understand the mathematical concept of Model assembly for a machine elements*
CLR-5 :	*Distinguish data exchange standards and common file types in CAD*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain knowledge in fundamentals of Graphics and transformations.*	*1*	*85*	*80*	*H*	*H*	*-*	*H*	*-*	*-*									
CLO-2 :	*Impart Knowledge in modelling of CAD system.*	*1*	*85*	*80*	*H*	*H*	*H*	*-*	*H*	*-*									
CLO-3 :	*Learn the various algorithm used in geometric modelling*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*H*										
CLO-4 :	*Understand the mathematical concept of Model assembly for a machine elements*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*										
CLO-5 :	*Distinguish data exchange standards and common file types in CAD*	*2*	*85*	*80*	*H*			*H*		*H*									

Duration (hour)		Fundamentals of Computer Graphics	Geometric Modelling	Visual Realism	Assembly and Tolerance	Graphics Standards
		10	10	08	09	08
S-1	SLO-1	*Design as a process, sequential and concurrent engineering.*	*Introduction to geometric modelling*	*Hidden line removal: Visibility of object views*	*Assembly modelling: Introduction, Part modelling.*	*Computer graphics: Introduction*
	SLO-2	*Computer Aided Design (CAD) and its architecture.*	*Wire frame modelling: Introduction*	*Visibility of object techniques*	*Assembly modeling: Representation Hierarchical relationship & Mating Condition.*	*Computer graphics: software and Database CAD Graphics*
S-2	SLO-1	*Computer graphics, co-ordinate system*	*Model, entities of wire frame modelling.*	*Visibility of object techniques: Sorting & Coherence*	*Assembly modeling: Types of Approach*	*Translator: Types*
	SLO-2	*Transformation types: Two and three dimensional.*	*Representation of synthetic curves: Hermite curve*	*Visibility of object technique: Priority and area orientation*	*Interferences of positions*	*Software standards: Graphical Kernel System (GKS)*
S-3	SLO-1	*Transformation in 2D and 3D: Translational, scaling.*	*Bezier curve.*	*Hidden surface removal: Back face, Scan line Algorithm*	*Tolerance: Introduction, need& concept of conventional.*	*Exchange Database : IGES*
	SLO-2	*Problems in translational scaling.*	*Problems on Bezier Curve*	*Hidden surface removal: Z-buffer Algorithm*	*Fits and Limits: MMC , LMC*	*Exchange Database :STEP*
S-4	SLO-1	*Transformation in 2D and 3D: Rotation, reflection*	*B-spline curves*	*Warnock's algorithm*	*Tolerance: Modelling Accumulation, Drafting and Manufacturing*	*Drawing Exchange Format & ACIS*
	SLO-2	*Problems in Rotation, reflection*	*Problems on B – Spline curve*	*Hidden solid removal: Ray-tracing algorithm.*	*Geometric tolerance: Representation and Types*	*Graphics Functions: Output Primitives*
S-5	SLO-1	*Two dimensional transformations: Problems on rotation,*	*rational curves*	*Shading: Model, surface*	*Tolerance analysis: Worst- case arithmetic method*	*Line attributes: types width , color*
	SLO-2	*2D Problems on scaling*	*Surface modelling: Introduction, model.*	*Shading: Enhancement, solid.*	*Tolerance analysis: Worst- case statistical*	*Curve attributes :Color , table & Grayscale*

					method	levels
S-6	SLO-1	*2D Problems on translation,*	*Parametric representation of analytic surface.*	*Shading: solid*	*Tolerance analysis: Worst- case arithmetic method problems*	*Area Fill Attributes : Style, pattern, soft*
	SLO-2	*2D Problems on, reflection.*	*Plane surface*	*Coloring: Models*	*Tolerance analysis: Worst- case statistical method problems*	*Character Attributes: Text ,Marker*
S-7	SLO-1	*Three dimensional transformations: Problems on rotation,*	*ruled surface*	*Coloring: Types*	*Monte Carlo simulation method*	*Processors : Design and Implementation*
	SLO-2	*3D Problems on scaling,*	*Parametric representation of synthetic surface: Coons and*	*Animation: Conventional, Computer & Engineering*	*Mass property calculations: First and second Moment of inertia*	*Processors :Error handling , testing and verification,*
S-8	SLO-1	*3D problems on translation*	*Parametric representation of Synthetic curve : Bicubic*	*Animation Types and Techniques*	*Mass property calculations: second Moment of inertia*	*Open Graphics Library (OpenGL): Introduction*
	SLO-2	*3D problems on reflection*	*Parametric representation of Bezier curve*	*Morphing: Types and model*	*Geometrical property: Curve Length, Surface Area*	*Open Graphics Library (OpenGL) : Types*
S-9	SLO-1	*Homogeneous co-ordinates.*	*Parametric representation of B Spline curve*		*Geometrical property: Volume: & Cross section Area*	*Communication standards for CAD systems*
	SLO-2	*Algorithms: Line, circle*	*Solid modelling: Introduction, models, entities*		*Properties of composites, mass property calculation by using CAD systems*	
S-10	SLO-1	*Clipping algorithm.*	*Solid modelling representation: Boundary representation.*			
	SLO-2	*Windowing and viewing.*	*constructive solid geometry.*			

Learning Resources	1. *Ibrahim Zeid, "Mastering CAD CAM", Tata McGraw-Hill Publishing Co, 2007.* 2. *Chris McMahon and Jimmie Browne, "CAD/CAM Principles", Practice and Manufacturing Management 2nd edition, Pearson Education, 1999.*	4. *William M Neumann and Robert F.Sproul, "Principles of Computer Graphics", McGraw-Hill Book Co.Singapore, 1989.* 5. *Donald Hearn and M. Pauline Baker, "Computer Graphics", Prentice Hall, Inc, 1992.* 6. *Foley, Wan Dam, Feiner and Hughes, "Computer Graphics Principles and Practice", Pearson Education, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Ak. Lakshminaraimhan, Senior Principal Engineer,Technip FMCAK lakshminaraimhan@technipfmc.com, Chennai	*2. Dr. R.sarala, Alagappa Chettiar college of Engineering and Technology, r.sarala@accetedu.in, karaikudi.*	*2. Mr.J.Arivarasan, SRMIST*

Course	18MHE408T	Course	MICRO ELECTRO MECHANICAL SYSTEMS	Course	*E*	*Professional Elective*	L	T	P	C

Code		Name		Category			3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Provide necessary fundamental knowledge in manufacturing and packaging of micro systems*
CLR-2 :	*Impart knowledge of behavior of mechanical and electrical elements at micro level*
CLR-3 :	*Emphasis on electrical and Thermal actuation in microsystems*
CLR-4 :	*Emphasis on Piezoelectric and Magnetic actuation in microsystems*
CLR-5 :	*Expose on MEMS applications in Automotive sector and Space exploration*
CLR-6 :	*Introduce computer aided simulation of microsystems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the operation and manufacturing of microsystems*	*1*	*85*	*80*	*H*	*L*	-	*L*	*L*	*M*		*L*	*M*	-	-	-	*M*	-	-
CLO-2 :	*Analyze the behavior of MEMS systems*	*2*	*85*	*80*	*H*	*H*	-	*H*	*L*	-		*L*	*M*	-	-	-	-	-	-
CLO-3 :	*Design micro sensors and actuators actuated by electrical and Thermal actuation*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	-	*H*	*L*	*M*	-	-	-	-	-	-
CLO-4 :	*Design micro sensors and actuators actuated by Piezoelectric and Magnetic actuation*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*L*	-	*H*	*L*	*M*	-	-	-	-	-	-
CLO-5 :	*Gain knowledge on different applications of MEMS devices*	*2*	*85*	*80*	*H*	*H*	-	*L*	*L*	*M*		*L*	*M*	-	-	-	-	-	-
CLO-6 :	*Simulate simple Microsystems*	*2*	*85*	*80*	*H*	*H*	-	*L*	*H*	-		*L*	*M*	-	-	-	-	-	-

		Introduction to MEMS & Microsystem Fabrication Processes	Mechanical and Electrical Conceptions	Sensing and Actuation-I (Electrical and Thermal)	Sensing and Actuation-II (Piezoelectric and Magnetic)	Mems Case studies
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Overview of MEMS,*	*Review of Semiconductor*	*Electrostatic sensors and actuators*	*Piezoresistivity gauge factor*	*MEMS inertial sensor in automobile airbag deployment*
	SLO-2	*Elements of MEMS, Applications*	*Carrier concentration in Silicon semiconductors*	*Parallel plate capacitors*	*Piezoresistive materials*	*MEMS vibratory gyroscope*
S-2	SLO-1	*Intrinsic characteristics of MEMS, Multidisciplinary nature of microsystem design and Manufacture*	*Calculation of Conductivity and resistivity of semiconductor Electron mobility in Silicon*	*Equilibrium position of parallel plate actuators*	*Applications of piezoresistive sensor*	*Optical MEMS*
	SLO-2	*Scaling Law of Miniaturization*	*Sheet resistivity Numerical Problems*	*Pull-in effect of parallel plate actuators*	*Inertia sensors, pressure sensors based on piezoresistivity*	*Digital Micro Mirror Devices*
S-3	SLO-1	*Simple problems related to miniaturization*	*Crystal planes and Orientations, General scalar relationship between stress and strain*	*Applications of Parallel plate capacitors, Inertia sensor*	*Tactile sensor*	*MEMS devices in Biotechnology*
	SLO-2	*Materials for MEMS: Silicon, Silicon Compounds and Polymers*	*Study of Flexural beams bending under simple loading conditions*	*Pressure sensors*	*Flow sensor*	*Scanning Tunnelling Microscope*
S-4	SLO-1	*Microsystem Fabrication Processes: Photolithography*	*Mechanical deformation of cantilever beam spring*	*Flow sensors*	*Piezoelectric sensing and actuation*	*Polymerase Chain reaction*
	SLO-2	*Ion Implantation*	*Deformation of torsional bars*	*Tactile sensors, Parallel plate actuators*	*Piezoelectric materials*	*Microsystems for DNA amplification*

S-5	SLO-1	*Diffusion*	*Discussing the Simple problems related to force constant*	*Interdigitated Finger capacitors*	*Piezoelectric Accelerometer*	*Fluidic MEMS, Micro channels*
	SLO-2	*Oxidation*	*Origin of intrinsic stress, Methods for characterization*	*Comb drive accelerometer*	*Acoustic sensors*	*Polymer MEMS, Liquid crystal Polymer, PDMS,PMMA*
S-6	SLO-1	*Chemical Vapor Deposition (CVD)*		*Thermal Sensing and Actuation*	*Tactile sensors*	*MEMS devices in space exploration*
	SLO-2	*Physical Vapor Deposition (PVD)*		*Thermal resistance*	*Flow sensors*	*Micro power sources, micro turbines*
S-7	SLO-1	*Surface micromachining*	*Control and compensation of bending*	*Thermal bimorph principle*	*Magnetic actuation*	*Introduction to NEMS*
	SLO-2	*LIGA Process*	*Analysis of essential elements of MEMS system dynamics*	*Thermal bimorph actuator*	*Essential concepts and principles*	*Nano fabrication*
S-8	SLO-1	*Bulk micromachining; Dry etching, Wet etching*	*Discussion*	*Accelerometer based on thermal transfer principle*	*Deposition of Magnetic materials*	*Nano devices*
	SLO-2	*Plasma etching, DRIE*	*Damping & Quality factor, Resonant Frequency*	*Thermal accelerometer with no moving mass*	*Fabrication of Magnetic coil*	*Nano manipulation*
S-9	SLO-1	*MEMS process integration strategies*		*Flow sensors based on thermal transfer principle*	*Magnetic motors*	*Computer aided simulation and design of MEMS devices Background to Finite element method*
	SLO-2	*Microsystem Packaging*	*Active Tuning of spring constant and resonant frequency*	*Infrared sensor*	*Magnetic beam actuation*	*Exposure to commercial software packages*

Learning Resources	1. *Tai- Ran Hsu, "MEMS and Microsystem Design and Manufacture" McGraw Hill Education (India) Private Limited, New Delhi, 2002.* 2. *Chang Liu, "Foundations of MEMS" 2nd edition, Dorling Kindersley India Pvt Ltd, 2012.* 3. *Rai-Choudhury.P., "MEMS and MOEMS Technology and Applications" Prentice Hall of Indian Indian Learning Private Limited, 2009.*	4. *NadimMaluf, "An Introduction to Microelectromechanical Systems Engineering" 2nd Edition, Artech House, 2004.* 5. *Reza Ghodssi, Pinyen, "MEMS Materials and Processes Handbook", Springer Science Business Media, 2011.* 6. *Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices and Structures" CRC Press, 2002.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	*-*	*30 %*	*-*	*30 %*	*-*	*30 %*	*-*	*30%*	*-*
Level 2	Apply Analyze	*40 %*	*-*	*40 %*	*-*	*40 %*	*-*	*40 %*	*-*	*40%*	*-*
Level 3	Evaluate Create	*30 %*	*-*	*30 %*	*-*	*30 %*	*-*	*30 %*	*-*	*30%*	*-*
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. C. Purushothaman, ABB India Ltd, Chennai, purushothaman.c@in.abb.com	*1. Dr.G.Sakthivel, VIT University, Chennai, sakthivel.g@vit.ac.in.*	*1. Dr.G.Murali, SRMIST*
2. Mr.J. Srinivasan, KONE Elevator India Private Limited,Chennai, srinikone@gmail.com	*2. Dr.R.AmuthaKannan, National University, Muscat,amuthakkannan@nu.edu.om.*	*2. Mr.N.Pradeep, SRMIST*

Course Code	18MHE409T	Course Name	AUTOMATION AND INTELLIGENT SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*To impart the basics of automation and intelligent systems.*
CLR-1 :	*Explain the fundamentals of automated systems.*
CLR-2 :	*Identify the elements of CIM and its construction.*
CLR-3 :	*Discuss about the knowledge based systems.*
CLR-4 :	*Apply the artificial intelligent and expert systems in manufacturing.*
CLR-5 :	*Develop the Artificial neural network system for manufacturing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Understand the basics of automation system and designing of simple automated system*	*2*	*75*	*75*	*H*	*L*	*H*	*L*	*M*	*H*	*L*	*L*	*M*	*M*	*H*	*H*	*L*	*M*	*-*
CLO-2 :	*Explain the modeling tools of Petri Nets and Quenching model*	*2*	*75*	*80*	*H*	*L*	*M*	*-*	*H*	*M*	*-*	*-*	*-*	*-*	*L*	*L*	*-*	*-*	*L*
CLO-3 :	*Analysis the Intelligent manufacturing system components and IMS architecture*	*3*	*80*	*85*	*H*	*-*	*M*	*L*	*H*	*L*	*-*	*M*	*L*	*M*	*M*	*M*	*-*	*-*	*-*
CLO-4 :	*Prescribe the structure of knowledge based systems and approaches in KBS*	*2*	*80*	*75*	*H*	*L*	*L*	*M*	*-*	*-*	*-*	*-*	*L*	*-*	*L*	*L*	*L*	*-*	*-*
CLO-5 :	*Learn the organizational platform in Janus system to implement the Holon control for Manufacturing.*	*3*	*85*	*80*	*H*	*-*	*L*	*M*	*H*	*M*	*L*	*L*	*-*	*L*	*L*	*L*	*-*	*-*	*H*
CLO-6:	*Understand the concept of Artificial Intelligence and Neural Network systems in Manufacturing*	*3*	*85*	*80*	*H*	*L*	*H*	*-*	*L*	*L*	*-*	*-*	*L*	*-*	*-*	*H*	*-*	*-*	*L*

Duration (hour)		Automation Systems	Modelling of Automation Systems	Computer Integrated Manufacturing Systems	Knowledge Based Systems	Machine Learning, Artificial Intelligence and Expert Systems
		09	09	09	09	09
S-1	SLO-1	*Introduction: Automation systems*	*Introduction of Modeling tools-Markov chain models*	*Introduction of CIMS Systems, CIM Definitions*	*Introduction of basic Knowledge Based Systems (KBS).*	*Introduction of Machine Learning*
	SLO-2	*Basic elements of automation system*	*Configuration of Markov model, Assumptions, application*	*Basic four plan Concept, Components, Benefits of CIMS*	*Basic components of Knowledge Based Systems (KBS).*	*Objectives of Machine Learning*
S-2	SLO-1	*Advantages, evolution of automation systems*	*Introduction of Quenching models, types of Quenching models*	*Structural and functional areas of CIMS Systems*	*Designing of Knowledge Based System(KBS)*	*Concepts of Machine Learning*
	SLO-2	*applications of automation systems*	*Various techniques of quenching models and applications*	*Features of CIM Wheel, CIM Evolution*	*Advantages and disadvantages of Knowledge Based System(KBS)*	*Types of Machine Learning and its algorithm with examples*
S-3	SLO-1	*Automation systems in Services*	*Introduction of Petri Nets models, classes of PN Models for manufacturing systems,*	*Introduction of Manufacturing Communication Systems*	*Application and limitation of Knowledge Based System(KBS)*	*Uses of Machine Learning*
	SLO-2	*Packaging and storage services*	*Basics of Petri Nets ,Examples*	*Types, layout of Manufacturing Communication Systems, Applications.*	*Introduction to Knowledge representation structure*	*Merits and Demerits of Machine Learning*
S-4	SLO-1	*Office automation systems*	*Types of Petri Nets models ,Properties of PN models,*	*Definition of Data redundancy, types , advantages of Data redundancy*	*Approaches in KBS.*	*Fundamental of Artificial Intelligence*
	SLO-2	*Stages of Growth, Basic activities , advantages and disadvantages of office Automation*	*Basics architecture of PN Models*	*Basic Definition of top-down and bottom-up approach volume of information,*	*Introduction to Engineering design for knowledge based reasoning*	*Concept and objective of Artificial Intelligence*

S-5	SLO-1	Types of functions integrated by OAS	Structural properties of Petri Nets models, applications	Objectives, comparison of top- down and bottom up approaches	Engineering design knowledge based reasoning in manufacturing	Architecture of Artificial Intelligence
	SLO-2	Documentation and Communication	Discussion	Important roles of top- down and bottom up approaches	Introduction to Multi- agent manufacturing system	Various types of design pattern in Artificial Intelligence
S-6	SLO-1	Designing of simple automation systems	Various modeling of Petri Nets,	Introduction of intelligent manufacturing system, basic definition	Designing of Multi- agent manufacturing system	Application and advantages of Artificial Intelligence
	SLO-2	Components of simple automated design	Analysis methods of PN models	Basic concept of IMS, Components of IMS,.	Advantages and disadvantages of Multi- agent manufacturing system	Conceptual learning Expert Systems
S-7	SLO-1	Interlocking between feed and opening of the door	Differences between simple Petri Nets and high level Petri Nets.	Basic Principles of IMS, IMS overview, tools used for IMS	Application and limitation of Multi- agent manufacturing system	Basics Function of learning Expert Systems
	SLO-2	Various design steps and implementation of simple Automation	Types of simple Petri Nets, functions, examples	IMS architecture, applications of IMS	Introduction to Holonic manufacturing systems	Fundamental of Neural Networks
S-8	SLO-1	Designing of multi level automation systems	Types of high level Petri nets ,	Introduction of IMS data flow, definitions	Designing Holonic manufacturing systems	Types of Neural Networks
	SLO-2	Design steps and process of Multi level automation	Functions of High level Petri Nets , examples	Process modeling of data flow diagram, Identify the object of DFD(Data Flow Diagram)	Control of Holonic manufacturing systems	Application and limitation of Neural Networks in manufacturing
S-9	SLO-1	Monitoring the temperature on the basis of supply of fuels,	Introduction of PRQN – ESP models, types of PRQN – ESP models	Fundamental of IMS Operation,	Advantages and disadvantages of Holonic manufacturing systems	Introduction of Artificial Neural Networks and Fuzzy Logics
	SLO-2	pressure, velocity and calorific value	Integrated PRQN – ESP models	Tutorial	Application and limitation of Holonic manufacturing systems	Introduction and Concepts of Fuzzy set , Biological neuron , Artificial neuron

Learning Resources	1. Mikel P. Groover , "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2014.Text / Audio / Video 2. T YagnaNarayana, "Artificial Neural Networks", Prentice Hall of India, 2009ext / Audio / Video 3. Andre Kusaic, "Intelligent Manufacturing Systems", Prentice Hall of India, 1989.	4. Hamid R. Parsaei and Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems", Prentice Hall of India, 2009. 5. Z. Zhou, Zude, Xie, Shane Shengquam, Chen, Dejun "Fundamentals of Digital Manufacturing Science", Springer Series in Advanced Manufacturing, Springer Verlag London Limited, 2012.

Learning Assessment												
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		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mrs..A.Priya ,Principal Engg, Technip FMC,apriya@technipfmc.com	1. Dr. B.Mohan, Professor,CEG,bmohan@annauniv.edu, Chennai	1. Ms.D.Gayathiri, SRMIST
2. Mr. Ak. Lakshminaraimhan, Senior Principal Engineer,Technip FMCAK Lakshminaraimhan@technipfmc.com	2. Dr. Dr.S.NeelavathyPari, Asst. Professor (Senior Grade), MIT,neela@annauniv.edu, Chennai.	2. Mr. K.Saravanan, SRMIST

Course Code	18MHE410T	Course Name	VIRTUAL INSTRUMENTATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	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 importance of virtual instrumentation and its benefit
CLR-2 :	Discuss about the various data acquisition devices and techniques
CLR-3 :	Discuss about the various interfacing techniques
CLR-4 :	Introduce the concepts of programming and VI
CLR-5 :	Learn simulation of various process using virtual instrumentation

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	Understand the importance and benefits of virtual instrumentation and its application	2	80	70	H	L	H	H	L	L	-	-	M	-	-	L	M	-	-
CLO-2 :	Understand various data acquisition methods	2	80	70	H	H	H	H	H	L	-	-	L	-	-	L	M	-	-
CLO-3 :	Understand standard interfaces to connect external device to PC	2	80	70	H	H	H	H	H	L	-	-	L	-	-	L	M	-	-
CLO-4 :	Program and develop VI for various system	2	80	70	H	H	H	H	H	L	-	-	M	-	-	L	M	-	-
CLO-5 :	Understand the application of virtual instrumentation in the industry process	3	80	70	H	H	H	H	H	L	-	-	M	-	-	L	M	-	-

		Introduction to virtual Instrumentation	Data Acquisition Techniques	Interfaces	Concept of Programming	Case Study
Duration (hour)		8	10	9	13	5
S-1	SLO-1	Concept of virtual instrumentation	Introduction to Data Acquisition methods	Introduction to various Interfaces	Concept of programming	Simulation of system using virtual instrumentation- Introduction
	SLO-2	Example	PC based data Acquisition	Interfacing External instrument to a PC	Various tools and software available	Simple temperature indicator
S-2	SLO-1	Historical perspective of virtual instrumentation	Board DAQ card	RS 232 Interface	Concept of VI and Sub VI	ON/OFF control
	SLO-2	Development of virtual instrumentation	Resolution and sampling Frequency	RS422,RS485 Interfaces	Example	Case study-Any industrial process
S-3	SLO-1	Block diagram of basic virtual instrumentation	I/O techniques and buses,	USB standard	Display Types	PID control
	SLO-2	Architecture of virtual instrumentation	Analog to digital converter, digital to analog converter	Example	Digital ,Analog	Case study-Any industrial process
S-4	SLO-1	Advantages over other conventional programming	Multiplexing of Analog Input	IEEE 488 standard	Display Types	CRO Emulation
	SLO-2	Example for comparison	Single ended and differential ended	Example	Chart , Oscilloscope type	Case study
S-5	SLO-1	Application of VI in mechatronics engineering	Case Study- Data acquisition using DAQ card	Serial Bus	Programming constructs: Loops.	Simulation of simple second order system
	SLO-2	Case Study	Concept of sampling, resolution, single and differential ended	Example	Programming constructs: Charts.	Case Study

S-6	SLO-1	*Review of Digital Instrumentation*	*Strategies for sampling multichannel analog input*	*Introduction to Bus protocol*	*Programming constructs: Arrays.*	
	SLO-2	*Representing Analog Signal in digital domain*	*Example*	*Various Example*	*Example*	
S-7	SLO-1	*Quantization*	*Concept of Universal DAQ card*	*MOD Bus*	*Programming constructs: Clusters*	
	SLO-2	*Sample and hold*	*Example*	*Example*	*Example*	
S-8	SLO-1	*Sampling Theorem*	*Use of Timers*	*CAN Bus*	*Programming constructs: graphs.*	
	SLO-2	*ADC and DAC*	*Example*	*Example*	*Example*	
S-9	SLO-1		*Use of Counter*	*Case Study (Communication protocols I2C,SPI,Serial)*	*Programming constructs: Case structure*	
	SLO-2		*Example*	*Interfacing sensor to the controller*	*Example*	
S-10	SLO-1		*Case Study*		*Programming constructs: sequence*	
	SLO-2		*Real time data acquisition process*		*Example*	
S-11	SLO-1				*Formula nodes*	
	SLO-2				*Local and global variables*	
S-12	SLO-1				*State machine*	
	SLO-2				*State machine*	
S-13	SLO-1				*Rtring and file input/output*	
	SLO-2				*Review of programming*	

Learning Resources	1. *Wells Lisa K and Travis Jeffrey, "LabVIEW for everyone", Prentice Hall, 1997.* 2. *Gary Johnson,"LabVIEW Graphical Programming", 4th edition, McGraw Hill, Newyork, 1997.*	3. *Mahesh L Chgani and Abhay R. Samant, " Labview Signal Processing", Prentice Hall of India, 1998.* 4. *James K, "PC Interfacing and Data Acquisition", Elsevier, 2002.6. Robert H. Bishop, "Learning with Labview", Prentice Hall of India, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	*1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com*	*1. R Ranjith Pillai , SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. G. Madhumitha ,SRMIST*

Course Code	18MHE411T	Course Name	MACHINE VISION AND IMAGE PROCESSING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Impart knowledge on the machine vision technology as a tool for industrial automation.*
CLR-2 :	*Understand specifications of vision hardware*
CLR-3 :	*Understand the fundamental algorithms and implement them.*
CLR-4 :	*Enable reading of current image processing research literature.*
CLR-5 :	*Gain the experience in applying image processing algorithms to industrial problems.*
CLR-6 :	*Get an introductory information related to 3-D vision and deep learning techniques*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment &Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Abstract the physics of light which defines the possibilities and limitations of a vision system.*	2	80	80	L	H	-	H	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Interpret the various specifications of a imaging system and select the right hardware based on understanding of scene constraints*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Develop the algorithms to enhance images.*	3	75	70	M	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Develop the algorithms that extract various types of attributes from digital images.*	3	85	80	M	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Appreciate the relevance of machine vision to mechatronics systems*	3	85	75	H	H	M	H	H	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*Apply the concepts of machine vision and image processing in various industrial applications*	3	80	70	H	H	M	H	L	-	-	-	L	L	-	L	H	M	-

		Introductory concepts	Image acquisition	Image processing	Image analysis	3-d vision & deep learning
Duration (hour)		7	10	10	8	10
S-1	SLO-1	*Introduction to course*	*Scene constraints*	*Introduction to machine vision software*	*Feature Extraction*	*Classification of 3-D Vision Techniques*
	SLO-2	*Related fields and Industries using vision*	*Performance requirement*	*Software selection criteria*	*Region Features*	*Active Vision - LIDAR*
S-2	SLO-1	*Physics of light*	*Fundamentals of lighting*	*Basics of digital image*	*Template Matching*	*Computational Stereo Vision*
	SLO-2	*Imaging modalities with light*	*Why Lighting is important?*	*Sampling and quantization effects*	*Issues to be addressed*	*Steps in stereo vision*
S-3	SLO-1	*Interactions of light*	*Light sources*	*Gray scale histogram*	*Methods of Template Matching*	*Introduction to Neural Neteorks*
	SLO-2	*Reflection and Refraction*	*Light sources - types and selection*	*Image processing*	*Linear Classification*	*Types of nueral networks*
S-4	SLO-1	*Introduction to machine vision system building*	*lighting techniques*	*Thresholding*	*Corner Detection*	*Back propogation learning*
	SLO-2	*Task Specification*	*lighting techniques - types and selection*	*Contrast stretching*	*Harris Corner Detector*	*Numerical problem*
S-5	SLO-1	*Design of the system*	*Machine vision lenses*	*Image smoothing in spatial domain*	*Keypoint matching*	*Concepts in machine learning learning*
	SLO-2	*Cost calculation*	*Filters*	*Image sharpening in spatial domain*	*Matching methods*	*The Deep Learning Idea*
S-6	SLO-1	*Development, Testing and commissioning*	*Image sensor specifications*	*Edge detection in spatial domain*	*Texture Analysis*	*Application of deep learning in computer vision*
	SLO-2	*Human visual system*	*Terminologies*	*Derivative operators*	*Approaches and methods*	*Concepts in deep learning*
S-7	SLO-1	*Structure of human eye*	*Sensor types based on sensing element*	*Two dimensional discrete Fourier transform*	*Co-occurrence Matrix*	*Convolutional layer of neural network*
	SLO-2	*Comparison with a machine vision system*	*Selection criteria*	*Frequency domain processing for image*	*Properties of Co-occurrence Matrix*	*Numerical problem*

				smoothing		
S-8	SLO-1		Camera computer interfaces	Frequency domain processing for image sharpening	Decision making considerations	Convolutional neural network (CNN) for image classification
	SLO-2		Types and selection	Low and high pass filters	For various machine vision applications	Architecture details
S-9	SLO-1		Camera parameters governing geometrical image formation	Binary morphology		Object detection using CNN
	SLO-2		Camera modeling	Basic Morphological operations		Single shot learning for object detection
S-10	SLO-1		Camera calibration	Non Linear filters		Improving deep learning algorithms
	SLO-2		Distortions	Color image processing		Optimizers

Learning Resources	1. Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing", 2008 Edition, Pearson Education 2. Eugene Hecht, A.R. Ganesan "Optics", 2001 Edition, Pearson India. 3. Alexander Hornberg, "Handbook of Machine Vision", 2006 Edition, Wiley .	4. EmanueleTrucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1998 Edition, Prentice Hall. 5. Ian Goodfellow, YoshuoBengio and Aaron Courvile, "Deep Learning", 2015 Edition, MIT Press.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	30 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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

Course Code	18MHE412T	Course Name	ADVANCED CONTROL SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHC201J*	Co-requisite Course	*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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Gain understanding of nonlinear dynamics*																		
CLR-2 :	*Utilize the concepts pertaining to optimal and robust control systems*																		
CLR-3 :	*Develop an understanding of model based predictive control.*																		
CLR-4 :	*Gain knowledge on the implementation of optimal state estimators.*																		
CLR-5 :	*Gain knowledge on the implementation of adaptive control schemes for systems*																		
CLR-6 :	*Impart knowledge of design and implementation of advanced control systems*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Demonstrate an understanding of nonlinear dynamics*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-2 :	*Identify the concepts pertaining to optimal and robust control systems*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-3 :	*Demonstrate an understanding of model based predictive control.*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-4 :	*Familiarize on the implementation of optimal state estimators.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-5 :	*Familiarize on the implementation of adaptive control schemes for systems*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*
CLO-6 :	*Demonstrate an understanding on the implementation of the design of advanced control systems*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*M*	*H*	*M*	-	*M*	*M*	*H*	*M*	*M*	*H*	*M*

		Non-linear systems	Robust control	Optimal control	Optimal estimation	Adaptive control
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Nonlinear Dynamics*	*Robustness*	*Principle Of Optimality*	*Overview Of Stochastic Processes*	*Need For Adaptive Control*
	SLO-2	*Common Physical Nonlinearities.*	*Sensitivity*	*Dynamic Programming*	*Probability And Random Variables*	*Adaptive Control Schemes*
S-2	SLO-1	*Concept Of Phase Plane Analysis*	*Analysis Of Robustness In System Parameters*	*Hamilton-Jacobi-Bellman Equation.*	*Spectral Analysis Of Stochastic Process,*	*Gain Scheduling*
	SLO-2	*Phase Portraits*	*Analysis Of Uncertainty In System Parameters*	*Hamilton-Jacobi-Bellman Equation.*	*Special Cases: Multivariate Normal Distribution.*	*Gain Scheduling*
S-3	SLO-1	*Singular Points*	*Robust Control Systems.*	*Calculus Of Variations*	*Linear Quadratic Regulator*	*Principle And Design*
	SLO-2	*Symmetry In Phase Plane Portraits*	*Design Of Robust Control Systems.*	*Pontryagin's Minimum Principle*	*Continuous And Discrete Form*	*Principle And Design*
S-4	SLO-1	*Non Linear Systems*	*PID Controlled Systems*	*Bang-Bang Control*	*Kalman Filters*	*Model Reference Adaptive Systems*
	SLO-2	*Equilibrium Points*	*Robust PID Controlled Systems.*	*Bang-Bang Control*	*Variants Of Kalman Filter*	*Principle And Approaches*
S-5	SLO-1	*Stability Analysis*	*Design Of Robust PID Controlled Systems.*	*Nonlinear Programming Methods*	*Extended Kalman Filter*	*The MIT Rule*
	SLO-2	*Lyapunov's Stability Criterion For Linear Systems.*	*Design Of Robust PID Controlled Systems*	*Direct Method*	*Unscented Kalman Filter*	*Determination Of Adaptation Gain.*
S-6	SLO-1	*Stability Analysis*	*Internal Model Control System.*	*Linear Quadratic Regulator Design*	*Kalman Filters : Continuous Time Versions.*	*Model Reference Adaptive Systems*
	SLO-2	*Lyapunov's Stability Criterion For Non-*	*The Robust Internal Model Control System.*	*Continuous Riccati Equation Forms.*	*Kalman Filters :*	*Design Of MRAS Using Lyapunov Theory.*

		Linear Systems.			Continuous Time Versions.	
S-7	SLO-1	Phase Plane Trajectories	Pseudo-Quantitative Feedback Systems.	Discrete Riccati Equation Forms.	Kalman Filters : Discrete Time Versions	Self-Tuning Regulators
	SLO-2	Construction Of Phase Plane Trajectories.	Design Of Pseudo-Quantitative Feedback Systems.	Linear Quadratic Regulator Design	Kalman Filters : Discrete Time Versions	Pole Placement Design.
S-8	SLO-1	Describing Function Fundamentals	Overview Of Model Predictive Control Key Elements Of MPC.	H_2 And H-Infinity Optimal Control.	Linear–Quadratic–Gaussian	Direct Self-Tuning Regulators.
	SLO-2	Describing Function Of Common Nonlinearities	Overview Of Model Predictive Control Key Elements Of MPC.	H_2 And H-Infinity Optimal Control.	Linear–Quadratic–Gaussian (LQG) Control Problem	Direct Self-Tuning Regulators.
S-9	SLO-1	Describing Function Analysis Of Nonlinear Systems	Optimal Control	Basics Of Convex Optimization	LQG Controller Design And Implementation.	Indirect Self-Tuning Regulators.
	SLO-2	Stability Analysis By Describing Function Method.	Overview Of Methods In Optimal Control.	Receding Horizon Principle.	LQG Controller Design And Implementation.	Indirect Self-Tuning Regulators.

Learning Resources	1. Richard C Dorf and Robert H Bishop, “Modern Control Systems”, 13th edition, Pearson Education, 2016 2. I J Nagrath, M Gopal, “Control Systems Engineering”, 6th edition, New Age International, 2018. 3. DesineniSubbaram Naidu, “Optimal Control Systems”, 1st edition, CRC Press, 2003.	4. Karl J Åström, BjörnWittenmark, “Adaptive Control”, 2nd edition, Dover Publication, 2008. 5. Roland S Burns, “Advanced Control Engineering”, Butterworth Heinemann, 2005. 6. Jean-Jacques E Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall of India-New Jersey, 1991.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (20%)	CLA – 2 (30%)	CLA – 3 (30%)	CLA – 4 (20%)#	
		Theory	Theory	Theory	Theory	Theory
Level 1	Remember Understand	40 %	30 %	30 %	20 %	30 %
Level 2	Apply Analyze	40 %	40 %	40 %	40 %	40 %
Level 3	Evaluate Create	20 %	30 %	30 %	40 %	30 %
	Total	100 %	100 %	100 %	100 %	-

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.JeganAmrithalingam, Asst Manager, RNTBCI,ecejegan@gmail.com	1. Dr.K.Rahimunnisa, EashwariEngineering College, Chennai, krahimunnisa@gmail.com	1. Mrs.T.S.Rajalakshmi, SRMIST
2. Mr. Reuben Fernandes, ATOM 360, India, wenisch@atom360.io	2. Dr.SrideviSathyaPriya, KarunyaInstituteofTechology and Science,s.d.s.priya@gmail.com	2. Mrs.G.Madhumitha, SRMIST

Course Code	18MHE413T	Course Name	INDUSTRIAL PROGRAMMABLE CONTROLLERS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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 architecture, parts and operation of PLC, Industrial PC and PAC*
CLR-2 :	*Equip with the knowledge of various controllers specifications*
CLR-3 :	*Familiarize with the Ladder Programming/other programming constructs*
CLR-4 :	*Analyze and select the appropriate controller for given applications*
CLR-5 :	*Apply the knowledge of PLC, IPC and PAC for solving typical industrial automation problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Describe the architecture, parts and operation of PLC, Industrial PC and PAC*	*2*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*H*	*H*	*H*
CLO-2 :	*Recognize various controllers specifications*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-3 :	*Develop the Ladder Programming/other programming for given applications*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-4 :	*Analyze and select the appropriate controller for given applications*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	-	-	-	-	-	-	*H*	*M*	*M*	*M*
CLO-5 :	*Apply the knowledge of PLC, IPC and PAC for solving typical industrial automation problems*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	-	-	-	-	-	-	*H*	*M*	*M*	*M*

		Programmable Logic Controllers (PLC)	Programming of PLC	Application of PLC-Case studies	Industrial PC	Programmable Automation Controllers (PAC)
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Industrial automation,-Overview of syllabus*	*Hardwired Logic vs Programmable Logic*	*Filling/Draining Control*	*Industrial PC-Introduction and evolution*	*Introduction to PACs*
	SLO-2	*Evolution of PLC , Features*	*Hardwired Logic vs Programmable Logic*	*Filling/Draining Control*	*Industrial PC-Introduction and evolution*	*FPGA based PACs*
S-2	SLO-1	*A short history of Industrial robots*	*Ladder programming*	*Car Park Control*	*Architecture of Generic Industrial PC*	*Compact RIO architecture*
	SLO-2	*Architecture/parts of PLC*	*Logic functions*	*Car Park Control*	*Architecture of Generic Industrial PC*	*Compact RIO architecture*
S-3	SLO-1	*Principles of operation*	*Latching*	*Interlocks, Priority determinism and example*	*Features of IPC*	*RT Processor*
	SLO-2	*Modifying the operation*	*Internal relay*	*Interlocks, Priority determinism and example*	*Types of industrial PCs*	*Reconfigurable I/O FPGA*
S-4	SLO-1	*Comparison with PC*	*Timers: On-delay - Off-delay - retentive timers*	*Part sorting*	*Types of industrial PCs*	*I/O modules-system configuration*
	SLO-2	*PLC selection criteria*	*Timers: On-delay - Off-delay - retentive timers*	*Part sorting*	*Comparison of Various types*	*I/O modules-system configuration*
S-5	SLO-1	*The I/O section-Discrete I/O modules-Analog I/O modules*	*Counters: Up-counter - down-counter - cascading counters and timers*	*Automatic control of warehouse door*	*Industrial control networks-Introduction*	*Software architecture-Programming modes*
	SLO-2	*Special I/O modules- specifications*	*Counters: Up-counter - down-counter - cascading counters and timers*	*Automatic control of warehouse door*	*Industrial control networks-Introduction*	*Scan interface and FPGA Interface modes*
S-6	SLO-1	*The CPU of PLC*	*Shift registers*	*Air-conditioning system*	*Architecture of Industrial control networks*	*Key considerations for using PAC*

	SLO-2	Memory design	Shift registers	Air-conditioning system	Architecture of Industrial control networks	Key considerations for using PAC
S-7	SLO-1	Programming terminal device	Handling analog inputs	Applications in Fluid power automation	Requirements of Industrial control networks	Motion control with PAC-case study
	SLO-2	Programming terminal device	Handling analog inputs	Applications in Fluid power automation	Industrial Field bus and Industrial Ethernet	Motion control with PAC-case study
S-8	SLO-1	Recording and retrieving data	Introduction to IL&SFC	PID Control in PLC	Industrial Field bus and Industrial Ethernet	Vision based system using PAC- Case study
	SLO-2	Recording and retrieving data	Introduction to IL & SFC	PID Control in PLC	Security issues and threats in industrial networks	Vision based system using PAC- Case study
S-9	SLO-1	HMI	Introduction to FBD and ST	PLC based servo system	Practical modern SCADA Protocols	Comparison between PLC, IPC and PAC
	SLO-2	HMI	Introduction to FBD and ST	PLC based servo system	Practical modern SCADA Protocols	Concluding Remarks

Learning Resources	1. Frank D. Petruzella, "Programmable Logic Controllers", 4th Edition, McGraw-Hill, 2011. 2. William Bolton, "Programmable Logic Controllers", 6th Edition, Elsevier Ltd, 2015 3. Dong Seong Kim, Hoa Tran DangPetruzella, "Industrial sensors and Controls in Communication Networks", Springer, 2019.	4. www.pacontrol.com/download/OMRON-PLC-Programming.pdf 5. http://www.ni.com/pdf/products/us/fullcriodevguide.pdf

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. ElayarajSivaraj, Tesla,California, elayaraj@hotmail.com	1. Dr. Manivannan P V, Indian Institute of Techonology, Chennai, pvm@iitm.ac.in	1. Mr.K.Sivanathan, SRMIST
2. Mr. VisweswaranJagadeesan , National Instruments, Bangalore visweswaran.jagadeesan@ni.com	2. Dr.D.Sathia Narayanan, National Institute of Ocean Technology, Chennai, sathianarayanan@niot.res.in.	2. Dr.R.Senthilnathan, SRMIST

Course Code	18MHE414T	Course Name	SPECIAL ELECTRICAL MACHINES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	18MHC102T	Co-requisite Course	18MHC204T	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 construction and principle of operation of Synchronous Reluctance Motors
CLR-2 :	Analyse the Performance ofStepping Motors
CLR-3 :	Understand the controllers applied in the operation of Switched Reluctance Motors
CLR-4 :	Analyse the Magnetic circuit andcharacteristics of Permanent Magnet Brushless D.C. Motors
CLR-5 :	Analyse the Permanent Magnet Synchronous Motorsfor suitable applications
CLR-6 :	Apply the Control circuits for different applications

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	PLO 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	Operate different types of Synchronous Reluctance Motors	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	Operate different types of Stepping Motors	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	Operate different types of Special machines	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	Analyze the control circuits for suitable actuation	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	Apply the different machines for suitable Application	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	Operate, Analyze and apply different machines and control circuits for suitable applications	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-

		Synchronous reluctance motors	Stepping motors	Switched reluctance motors	Permanent magnet brushless d.c. Motors	Permanent magnet synchronous motors
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Constructional features	Constructional features	Constructional features	Constructional features	Constructional features
	SLO-2	Constructional features	Constructional features	Constructional features	Constructional features	Constructional features
S-2	SLO-1	Types	Principle of operation	Principle of operation	Principle of operation	Principle of operation
	SLO-2	Types	Principle of operation	Principle of operation	Principle of operation	Principle of operation
S-3	SLO-1	Axial and radial air gap motors	Variable reluctance motor	Torque prediction	Types	EMF and torque equations
	SLO-2	Axial and radial air gap motors	Variable reluctance motor	Torque prediction	Types	EMF and torque equations
S-4	SLO-1	Operating principle	Hybrid motor	Power controllers	Magnetic circuit analysis	Reactance
	SLO-2	Operating principle	Hybrid motor	Power controllers	Magnetic circuit analysis	Reactance
S-5	SLO-1	Reluctance	Single and multi stack configurations	Non-linear analysis	EMF and torque equations	Phasor diagram
	SLO-2	Reluctance	Single and multi stack configurations	Non-linear analysis	EMF and torque equations	Phasor diagram
S-6	SLO-1	Phasor diagram	Theory of torque predictions	Microprocessor based control	Power controllers	Power controllers - Converters
	SLO-2	Phasor diagram	Theory of torque predictions	Microprocessor based control	Power controllers	Power controllers - Converters
S-7	SLO-1	Characteristics	Linear and non-linear analysis	Characteristics	Motor characteristics	Volt-ampere requirements
	SLO-2	Characteristics	Linear and non-linear analysis	Characteristics	Motor characteristics	Volt-ampere requirements
S-8	SLO-1	Vernier motor	Characteristics	Computer control	controllers	Torque speed characteristics
	SLO-2	Vernier motor	Characteristics	Computer control	controllers	Torque speed characteristics
S-9	SLO-1	Applications	Drive circuits	Applications	Applications	Microprocessor based control
	SLO-2	Applications	Drive circuits	Applications	Applications	Microprocessor based control

Learning Resources	1. *T.J.E. Miller, „Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.* 2. *P.P. Aearnley, „Stepping Motors – A Guide to Motor Theory and P* 3. *ractice", Peter Perengrinus, London, 1982.*	4. *T. Kenjo, „Stepping Motors and Their Microprocessor Controls", Clarendon Press London, 1984.* 5. *T. Kenjo and S. Nagamori, „Permanent Magnet and Brushless DC Motors",Clarendon Press, London, 1988.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	18MHE415T	Course Name	DIGITAL MANUFACTURING	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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 :	*To learn about CAE, PLM and numerical control machining integration technology.*
CLR-2 :	*To be familiar in interfacing and Communication with industrial machinery.*
CLR-3 :	*To know to formulate manufacturing computational model.*
CLR-4 :	*To gain knowledge about intelligent controls used in various machinery environment.*
CLR-5 :	*To know about future development in digital manufacturing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Gain knowledge in fundamentals of Digital Manufacturing*	*1*	*85*	*80*	*H*	*H*	*-*	*H*	*-*	*-*									
CLO-2 :	*Impart Knowledge in industrial machinery*	*1*	*85*	*80*	*H*	*H*	*H*	*-*	*H*	*-*									
CLO-3 :	*Learn the information characteristics of manufacturing*	*1*	*85*	*80*	*H*	*H*	*H*	*H*	*H*										
CLO-4 :	*Understand the concept ofintelligent control in digital manufacturing.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*H*										
CLO-5 :	*To impart future development and application of digital manufacturing.*	*2*	*85*	*80*	*H*			*H*		*H*									

Duration (hour)		Introduction	Modeling	Manufacturing Information System	Intelligent control	Future developments
		9	9	9	9	9
S-1	SLO-1	*concepts of digital manufacturing*	*manufacturing computational model*	*information characteristics of manufacturing*	*Introduction to intelligent control in digital manufacturing*	*Future development and application of digital manufacturing*
	SLO-2	*Introduction to CIM and digital manufacturing.*	*Modeling theory of digital manufacturing,*	*Information activities*	*Intelligent multi information sensing.*	*Various digital technologies in product lifecycle*
S-2	SLO-1	*Product life cycle management (PLM).*	*basic concepts of computing manufacturing methodology,*	*Manufacturing informatics.*	*Concept of multi information sensing.*	*Cax technology integration.*
	SLO-2	*Applications of PLM*	*Application of C space*	*Measurement of manufacturing information*	*Application of sensor in processing*	*Digital equipment*
S-3	SLO-1	*Product data management (PDM).*	*Application of screw space.*	*Basic concept of measurement of Manufacturing information*	*Tool condition monitoring.*	*Digital processing technology.*
	SLO-2	*Applications of PDM*	*Virtual Prototyping*	*synthesis of manufacturing information*	*Mechanism of tool condition monitoring*	*Introduction to MEMS*
S-4	SLO-1	*Virtual environment for digital manufacturing.*	*Basic theory of virtual prototyping*	*Mechanism of synthesizing manufacturing information.*	*Intelligent multi information fusing*	*Basic concept and application of MEMS in Digital manufacturing*
	SLO-2	*Application of virtual environment (DM)*	*Application of virtual prototyping*	*Materialization of manufacturing information*	*Elements of multi information fusing*	*Basic concept and application of NEMS in Digital manufacturing*
S-5	SLO-1	*Operation mode of digital manufacturing system.*	*Reverse Engineering*	*Basic layout of Materialization of manufacturing information*	*Multi sensor fusion in tool state monitoring.*	*micro nanoequipement*
	SLO-2	*Mechanism of operation mode*	*Basic theory and application of Reverse*	*Integration model for manufacturing*	*Self learning*	*Basic concepts of micro nanoequipement*

			Engineering.	information.		systems.
S-6	SLO-1	Architecture of digital manufacturing system.	Discrete model of manufacturing computing.	Block diagram of integration model for manufacturing information.	Autonomy	Extremalization of digital manufacturing
	SLO-2	Introduction to CAE	Discrete model of controlled process in manufacturing	Mechanism of integration model	Compatibility	Complex mechanical system modeling.
S-7	SLO-1	CAE:engineering products	Information model of manufacturing computing.	Introduction to sharing manufacturing resources.	Openness of sensor fusion in tool state monitoring.	Complex electrical system modeling.
	SLO-2	Design representation	Geometric modeling	Principle of sharing manufacturing resources.	Tool condition monitoring based on fuzzy theory	Digital manufacturing Technology in Micro Nano Manufacturing
S-8	SLO-1	design process	theoretical foundation for geometric modeling	.mechanism of sharing manufacturing resources	Tool condition monitoring based on neural network.	Bionic Machinery
	SLO-2	Role of cad.	Geometric modeling forms.	Application of Sharing manufacturing resources.	Data mining applied to digital manufacturing	Application of bionic Machinery in digital manufacturing
S-9	SLO-1	Introduction to caX technology	Geometric reasoning in manufacturing computing.	Introduction to manufacturing information security	Application of data mining in digital manufacturing	Bio-Robot
	SLO-2	Basic concepts of caX technology	Application of geometric modelling in manufacturing computing	Basic theory of manufacturing information security.	Knowledge based manufacturing system.	Application of bio robot in digital manufacturing

Learning Resources	1. Zudezhou, Shanexie, Dejunchen, "fundamentals of digital manufacturing science". Springer, 2012. 2. Lihui, Wang, Andrew, Y C Nee, "Collaborative Design and Planning for Digital Manufacturing", springer, 2009. 3. Saaksvuori, Antti, Anselmi, Immonen, 'Product Lifecycle Management', Springer New York, 2008. 7. Stark, J., "Product Lifecycle Management - 21st Century Paradigm for Product Realisation", Springer, 2005. 8. Vukicajovanovic, Michealdebevee. "Applications of digital manufacturing in manufacturing process support" proceedings of IAJC/ ISAM, 2014.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%) #			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2.Mr.V.G. Balaji, Design Engineer, Rotork control, India private limited, balaji.govindan@rotork.com , Ambattur,	2. Dr. R.sarala,AlagappaChettiar college of Engineering and Technology, Manufacturing department, r.sarala@accetedu.in, karaikudi.	2. Dr. B. K. Vinayagam, SRMIST

Course Code	18MHE416T	Course Name	PROCESS CONTROL ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Identify the need for process control
CLR-2 :	Gain the knowledge on different controller modes
CLR-3 :	Build the various concepts of auto tuning
CLR-4 :	Utilize the control algorithm in pneumatic
CLR-5 :	Gain knowledge of multi loop control system
CLR-6 :	Introduce the knowledge of non-linear control algorithms

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	Knowledge of process control	2	75	70	H	M	M	H	M	-	-	-	M	M	-	H	H	H	H
CLO-2 :	Knowledge about the different controller modes	3	75	70	H	M	M	H	M	-	-	-	M	M	-	H	M	M	M
CLO-3 :	Design various control tuning methods	3	75	70	H	M	M	M	M	-	-	-	M	M	-	H	L	L	L
CLO-4 :	Application of control algorithm in pneumatic	3	75	70	H	M	M	-	M	-	-	-	-	M	-	H	M	M	M
CLO-5 :	Evaluate about the multi loop control system	3	75	70	H	M	M	H	M	-	-	-	M	M	-	H	L	L	L
CLO-6 :	Interpret the knowledge of non-linear control algorithms	3	75	70	H	M	-	H	H	-	-	-	M	M	-	H	H	H	H

		Introduction to Process Control	Controller Modes and Tuning	Final Control Elements	Multi Loop System	Nonlinear Systems and Intelligent Controllers
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Process control: Introduction,	First order system,	Basic of I/P converter.	Need, types of feed-forward controller	Non-linear elements in loop: Limiters
	SLO-2	Need for process control, terminologies.	second order system	Description about I/P converter.	Introduction to steady state and dynamic,	Non-linear elements in loop: dead zones
S-2	SLO-1	Characteristics of process.	Definition of Multi position action and floating action	Introduction of Pneumatic and electric actuators	Mathematical equation for steady state and dynamic feed-forward control	Non-linear elements in loop :backlash
	SLO-2	Liquid level control system Introduction	Need of Multi position action and floating.	Description about Pneumatic and electric actuators	Mathematical equation for dynamic feed-forward control	Non-linear elements in loop: dead band velocity.
S-3	SLO-1	Block diagram of Liquid level control system	Diagram of Multi position action and floating action:	Control algorithm for Servo motor	Definition of ratio control	Introduction of Limiter, negative resistance.
	SLO-2	Description of control elements used in liquid level control	Application of Multi position action, floating action:	Control algorithm for Stepper motor	Block diagram of ratio control, uses of ratio control.	Description of Limiter, negative resistance
S-4	SLO-1	Introduction of temperature control system	Introduction of PI, PD, PID controllers	Definition and need of Valve positioner control valves	Definition of cascade controller for heat exchanger	Introduction of optimal controller
	SLO-2	Block diagram of temperature control system	Block diagram and mathematical model of PI Controller	Types and configuration of valve position.	Advantages of cascade control	Definition of optimal controller
S-5	SLO-1	Description of control elements used in	Block diagram and mathematical model of	Introduction of control valves.	Adaptive control: Definition, objective,	Need for an optimal controller

		temperature control.	PD Controller		types, gain schedule adaptive controller.	
	SLO-2	Explanation about temperature control	Block diagram and mathematical model of PID Controller	Characteristics of control valves.	Block diagram description of adaptive control	Structure of an optimal controller.
S-6	SLO-1	Introduction of process dynamics	Basic Selection criteria for controllers.	Inherent characteristics of control valves.	Inferential control: Need, inferential controller for distillated column	Introduction of Dynamic matrix controller (DMC)
	SLO-2	Elements of process dynamics	Description Selection criteria for controllers.	Installed characteristics of control valves.	block diagram description of Inferential control	Definition of Dynamic matrix controller
S-7	SLO-1	Interacting systems	Need of controller tuning,	Introduction of Mathematical modeling of pneumatic control valve.	Split-range control, objective of split range control	Structure of Dynamic matrix controller
	SLO-2	Non interacting systems	Criteria for good control.	Description of Mathematical modeling of pneumatic control valve.	Block diagram for split range control.	tuning parameters required to implement Dynamic matrix controller
S-8	SLO-1	Degrees of freedom: Definition	Tuning methods: Basic of Choen-Coon method.	Valve body	Introduction of Internal mode control	Introduction of self-tuning controller
	SLO-2	Determination of degrees of freedom.	Description of Choen-Coon method.	Commercial valve` bodies	Principle and structure of Internal mode control	Need for self-tuning controller
S-9	SLO-1	Introduction of Continuous and batch process.	Introduction of Process identification for controller tuning.	Control valve sizing	Principle of Model predictive control	Structure of self- tuning controller.
	SLO-2	Description about Continuous and batch process.	Description of Process identification for controller tuning.	Cavitation and flashing	Theory of model predictive control, applications.	Case study: Process control in chemical plant.

Learning Resources	1. David A Bell., "Electronic devices and circuits", Oxford Publication., 2008. 2. Robert Boylestad and Louis Nashelsky., "Electronic devices and circuit theory", Prentice Hall., 7th edition, 2005.	3. D.Roy Choudhury, ShailB.Jain. "Linear integrated circuits", New Age International publishers, 2010. 4. J.B. Gupta., "Electronic devices and Circuits", Sanjay Kumar Kattaria Publication, 2010. 5. Milman and Halkias.C. "Electronic devices and circuits", Tata McGraw Hill publications, 2001.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE417T	Course Name	APPLIED MECHATRONICS SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Understand the design process and integrated design issues in mechatronics system
CLR-2 :	Apply the concept of robots used in different applications
CLR-3 :	Apply the concept of mechatronics system in medical application.
CLR-4 :	Apply the concept of mechatronics system in automobile application.
CLR-5 :	Apply the concept of mechatronics system in various industrial applications.
CLR-6 :	Utilize the concept of mechatronics system design into robotics, automobile and other industrial applications.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	Analyze the mechatronics system process into various applications.	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	Build parallel manipulator ,wall climbing, firefighting robot and obstacle avoidance robot	2	85	80	H	H	M	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	Build a robot for Neuro rehabilitation, mechatronic assistant for laparoscopic solo surgery, Exoskeleton and powered wheelchair	2	85	80	H	H	M	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	Build a system for cruise control, ABS, suspension, unmanned ground vehicle and measurement system in automobile applications.	2	85	80	H	H	M	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	Build a system for thermal cycle fatigue failure, PH level neutralization system and CNC controlled drilling machine in to industrial applications	2	85	80	H	H	M	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	Build the mechatronics system into various applications	2	85	80	H	H	M	H	M	-	L	L	M	-	-	-	-	-	-

		Introduction	Robotic Applications	Medical Applications	Automobile Applications	Other applications
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Mechatronics design concept and framework.	Case study 1: Parallel manipulators: state of art and perspectives	Application of robotics and mechatronic systems to neuro rehabilitation: Overview.	Electronics car engine management system	Case study 1:Thermal cycle fatigue of a ceramic plate
	SLO-2	Overview of mechatronics key elements.	Theoretical aspects of parallel manipulators and Practical applications	Robotic systems for upper limbs rehabilitation.	Stepper motor and vacuum operated throttle actuator	Case study 2:Strain gauge weighing system
S-2	SLO-1	Definition of mechatronics: Sequential integration and concurrent integration.	Development of parallel manipulator	Robotic systems for lower limbs rehabilitation.	Adaptive cruise control system	Case study 3:pH control system
	SLO-2	Integrated design issues in mechatronics.	Direct and inverse kinematics	Material and methods of neurorehabilitation system.	Adaptive cruise control system	Case study 3:pH control system
S-3	SLO-1	Introduction to real time interfacing	Bio parallel mechanism of mastication robot	Mechatronic systems for the functional assessment and the movement analysis.	Antilock braking system	Case study 4: Skip control of a CD player
	SLO-2	Elements of Data acquisition and control system	Mandibular movement and its parallel mechanism	Open issues.	Antilock braking system	Case study 4: Skip control of a CD player

S-4	SLO-1	Transducer and signal conditioning	Case study 2: Overview of a bio-inspired small sized wall climbing caterpillar Robot.	Overview of postural mechatronic assistant for laparoscopic solo surgery.	Electronics suspension control system	Case study 5: Position control of permanent magnet dc gear motor
	SLO-2	Transducer and signal conditioning	System architecture and Control methods of a bio-inspired Robot.	Overview of postural mechatronic assistant for laparoscopic solo surgery.	Electronics suspension control system	Case study 5: Position control of permanent magnet dc gear motor
S-5	SLO-1	Devices for data conversion	Climbing mechanism of the caterpillars.	Exoskeleton development and control	Electronic steering control for 4WS configuration	Case study 6: Testing of transportation bridge surface materials.
	SLO-2	Data conversion process	Mechanical module design and inchworm configuration realization, control realization.	Human robot interface	Low tire pressure warning system	Case study 6: Testing of transportation bridge surface materials.
S-6	SLO-1	Linking HMI design and system design	Locomotion control.	Wearable exoskeletal rehabilitation robot for interactive therapy	Automatic car parking system	PC based computer numerically controlled (CNC) drilling machine
	SLO-2	Human machine interface design process.	Case study 3: Firefighting Robot, Multiple interfaces based firefighting Robot.	Robot controller and therapy modes	Fuel quantity, coolant temperature measurement system	PC based computer numerically controlled (CNC) drilling machine
S-7	SLO-1	HMI design method	Case study 4: Torque cancelling system for quick-motion robots	Force sensing in medical robotics	Oil pressure and vehicle speed measurement system	Auto control system for green house temperature
	SLO-2	Designing human-automation interaction	Case study 4: Torque cancelling system for quick-motion robots	Haptic feedback using robotics surgery	Onboard diagnosis system	Mechatronics design of coin counter
S-8	SLO-1	Human error, interaction and the development of safety -critical systems	Case study 5: Recognition of finger motions for bio electric prosthetic hand via surface EMG	Model based fault detection and isolation for a powered wheelchair	Series hybrid electric vehicle	Magnetic levitation system
	SLO-2	Human error, interaction and the development of safety -critical systems	Case study 5: Recognition of finger motions for bio electric prosthetic hand via surface EMG	Model based fault detection and isolation for a powered wheelchair	Parallel hybrid electric vehicle	Washing machine control.
S-9	SLO-1	Cognitive function analysis in the design of human and machine multi agent system	Case study 6: Swimming Mechanism for robotic fish	Accurate positioning for intervention on a beating heart using crawling robot	Mechatronics design of an unmanned ground vehicle for military applications: Historical perspective, Current military systems	Electronic control of a balancing robot.
	SLO-2	Cognitive function analysis in the design of human and machine multi agent system	Case study 6: Swimming Mechanism for robotic fish	Accurate positioning for intervention on a beating heart using crawling robot	Design considerations, hardware implementation of unmanned ground vehicle, Vehicle software architecture.	Pneumatic controlled car park barrier system.

Learning Resources	1. Robort H Bishop,"Mechatronics an introduction" ,Taylor and Francis, 2nd edition, 2003 2. Annalisa Melilla, Donato Di Paola and GraziaCicirelli, "Mechatronic Systems, Applications", InTech publisher, 2010 3. Bolton, "Mechatronics - Electronic Control Systems in Mechanical and Electrical Engineering", 2nd edition, Addison Wesly Longman Ltd., 2007.	4. Devdasshetty, Richard A. Kolkm, "Mechatronics System Design", PWS Publishing company, 2nd edition, 2010. 5. M. D. Singh, J. G. Joshi, "Mechatronics", Prentice Hall of India private limited, 2006. 6. William B. Ribbens, Norman P. Mansour",Understanding Automotive Electronics", 6th edition,Elsevier science,2013.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	*100 %*		*100 %*		*100 %*		*100 %*		*100 %*	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course Code	15MHE418T	Course Name	REAL TIME EMBEDDED SYSTEMS	Course Category	C	Professional Core	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHC205J*	Co-requisite Course	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	Data Book/Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the basics of Embedded System*
CLR-2 :	*Perceive the concept of interrupts,memory and I/O management*
CLR-3 :	*Study the functions and scheduling of real –time operating systems*
CLR-4 :	*Learn the concept of semaphore,Queue and pipes*
CLR-5 :	*Know the different approach of a Real Time characteristics*
CLR-6 :	*Implement the concept of interrupts with an interfacing applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Explain the fundamentals of embedded system design with real time system*	2	90	85	H	L	H	L	M	-	H	-	-	-	-	L	M	-	M
CLO-2 :	*Analyze the fundamental concepts and can control with OS*	2	90	80	H	L	M	L	M	L	M	-	-	H	-	H	M	M	L-
CLO-3 :	*Evaluate the feasible algorithm and interrupts with interface applications*	2	90	85	H	L	H	L	M	L	M	-	-	H	-	M	M	H	M
CLO-4 :	*Implement the concept of RTOS and interrupts with interface*	2	95	90	H	L	H	L	M	-	M	-	-	M	-	M	M	H	M
CLO-5 :	*Analyse real time systems with regard to keeping time and resource restrictions*	2	90	85	H	L	M	L	H	L	M	-	-	M	-	M	H	H	H
CLO-6 :	*Know the concepts of interfacing applications*	2	85	85	H	L	H	M	M	-	-	-	-	M	-	M	M	H	M

		Introduction to Embedded System	Interrupts in Embeddded Systems	Overview of RTOS	Real-Time Characteristics	Communication Interfacing
Duration (hour)		09	09	09	09	09
S-1	SLO-1	*Introduction to the course and Discussion*	*Terminologies of an Embedded System.*	*Introduction*	*Introduction to Real time Characteristics*	*Introduction to converters and its types*
	SLO-2	*Embedded computers,Characteristics of embedded computing,challenegs in embedded computing system design*	*Gates and timing diagram*	*Multiple task and Multiple processes:Task and Processess,Multirate Systems*	*Algorithm:Clock driven approach*	*Types od ADCs and its working principle*
S-2	SLO-1	*Embedded System Design process:Requirements,Specification*	*Memory and its types*	*Timing requirements on process,CPU metrics*	*Weighted round robin approach*	*Types of DACs and its working principle*
	SLO-2	*Architecture Design*	*Memory and its types*	*Process stateandscheduling,some scheduling policies*	*Weighted round robin approach*	*Types of DACs and its working principle*
S-3	SLO-1	*Designing of hardware components*	*Microprocessor buses*	*Running periodic process,RTOS task and task state*	*Priority Driven Approach:Introduction and Concepts*	*Introduction to programmable Interface with A/D and its working principle*
	SLO-2	*Designing of software components*	*Programming the Input and Output Devices*	*Preemptive Real Time Operating Systems,Multithread preemptive schedule*	*Priority Driven Approach:Introduction and Concepts*	*Introduction to programmable Interface with A/D and its working principle*
S-4	SLO-1	*System Integration*	*Direct Memory Access*	*Priority Based Scheduling:Introduction and its types*	*Example of Priority Driven Approach*	*Introduction to programmable Interface with D/A and its working principle and Digital Voltmete*
	SLO-2	*System Integration*	*Direct Memory Access*	*Rate-Monoitic Scheduling*	*Example of Priority Driven Approach*	*Introduction to programmable Interface with D/A and its working principle and*

						Digital Voltmete
S-5	SLO-1	*Formalism for System Design:Structural Description*	*Interrupts: Built interrupts*	*Earliest Deadline First scheduling.*	*Dynamic versus Static systems*	*Introduction and working principle of Control robot system*
	SLO-2	*Formalism for System Design:Structural Description*	*Interrupts basis: Supervisemode, Exceptions and Traps*	*Evaluation of operating systems performance*	*Dynamic versus Static systems*	*Introduction and working principle of Control robot system*
S-6	SLO-1	*Formalism for System Design:Behavioral Description*	*Shared Data problem*	*Design of Telephone Answering Machine*	*Effective release Times and deadline*	*Introduction and working principle of Pulse Width Modulation*
	SLO-2	*Formalism for System Design:Behavioral Description*	*Disadvantage and interrupt latency*	*Design of Telephone Answering Machine*	*Effective release Times and deadline*	*Introduction and working principle of Motor Speed Controller*
S-7	SLO-1	*Design Example: Data Compressor*	*Embedded System evolution trends*	*Process synchronizationand Message queues.*	*Optimality of the Earliest Deadline First(EDF) algorithm:Introduction*	*Serial Communication and parallel Communication*
	SLO-2	*Design Example: Data Compressor*	*Embedded System evolution trends*	*Mailboxes,Pipes,critical selection*	*Optimality of the Earliest Deadline First(EDF) algorithm:Introduction*	*Wireless Communication*
S-8	SLO-1	*Design Example: Data Compressor*	*Interrupt routines in an RTOS environment*	*Semaphores: Classical synchronization problem, deadlocks.*	*Real Time concepts of EDF*	*Serial Protocols:I^2C,CAN and USB*
	SLO-2	*Design Example: Data Compressor*	*Interrupt routines in an RTOS environment*	*Semaphores: Classical synchronization problem, deadlocks.*	*Real Time concepts of EDF*	*Serial Protocols:I^2C,CAN and USB*
S-9	SLO-1	*Design Example:Alarm Clock*	*Real time clock*	*Basic Design using a Real-Time Operating System:Principle*	*Challenges in validating timing constraints in priority driven systems*	*Parallel Protocols:PCI and ARM Bus*
	SLO-2	*Design Example:Alarm Clock*	*System Clock*	*Encapsulating semaphores and Queues,Hard Real –Time Scheduling Considerstions*	*Off-line versus online scheduling*	*Wireless Protocols:IrDA,Bluetoothand IEEE 802.11*

Learning Resources	1. *Wayne Wolf,"Computers as Components:Principles of Embedded Computing System Design", Morgan Kauffman Publishers,2011* 2. *Frank Vahid and Tony Givargis,"Embedded SystmeDesign: AUnifiefd Hardware/Software Introduction", John Wiley and Sons, 2002.*	3. *David E.Simon, "An Embedded Software Primer", Pearson Education Asia, 2001.* 4. *RajKamal, "Embedded Systems",Tata McGraw Hill,2009* 5. *NPTEL Engineering Mechanics Lectures by IIT Guwahati 'https://nptel.ac.in/courses/112103109/'*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	*40 %*	-	*20 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Understand										
Level 2	Apply	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
	Analyze										
Level 3	Evaluate	*20 %*	-	*45 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Create										
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE419T	Course Name	INTELLIGENT CONTROL SYSTEMS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*18MHE412T*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	Data Book/Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the basics of fuzzy logic*
CLR-2 :	*Impart knowledge on the learning in neural network systems*
CLR-3 :	*Gain knowledge on the Hybrid Intelligent Systems*
CLR-4 :	*Impart knowledge on controllers based on fuzzy logic.*
CLR-5 :	*Design control systems based on artificial neural networks.*
CLR-6 :	*Impart the knowledge of advanced control systems for implementation.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Comprehend the basics of fuzzy logic*	*1*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-2 :	*Understand the learning in neural network systems*	*1*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-3 :	*Familiarize with the controllers based on fuzzy logic.*	*1*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-4 :	*Demonstrate synthesis of controllers based on fuzzy logic.*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-5 :	*Implement control systems based on artificial neural networks.*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*
CLO-6 :	*Implement control system based on fuzzy or neural network*	*2*	*85*	*80*	*H*	*H*	*M*	*M*	*M*	*L*	*M*	*L*	*L*	*L*	*L*	*M*	*H*	*H*	*H*

		Fuzzy logic	Artificial neural networks	Hybrid intelligent systems	Fuzzy control	Neural control
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Intelligent Systems*	*Artificial Neural Networks*	*Neuro-Fuzzy Systems*	*Knowledge-Based Fuzzy Control*	*Overview Of Supervisory Control.*
	SLO-2	*Intelligence In Machines*	*Operation Of A Single Artificial Neuron.*	*Fuzzy Basis Function Networks*	*Fuzzy PID Control*	*Direct Inverse Control*
S-2	SLO-1	*Intelligent Control System Structure*	*Network Architectures*	*Adaptive Neuro-Fuzzy Inference System - ANFIS*	*Knowledge-Based Fuzzy Control*	*Direct Learning Schemes.*
	SLO-2	*Soft Computing Techniques For Intelligent Control*	*Feed Forward Networks*	*Adaptive Neuro-Fuzzy Inference System - ANFIS*	*Model Reference Based Fuzzy Control*	*Indirect Learning Schemes.*
S-3	SLO-1	*Fuzzy Logic Systems*	*Radial Basis Function Networks*	*Training Algorithm -Supervised Algorithm*	*Fuzzy Control.*	*Model Reference Neural Adaptive Control - Direct Control*
	SLO-2	*Fuzzy Set Theory*	*Definition And Types Of RBF*	*Training Algorithm -Supervised Algorithm*	*Hybrid Fuzzy Control*	*Model Reference Neural Adaptive Control - Direct Control*
S-4	SLO-1	*Fuzzy Operations*	*Recurrent Networks*	*Training Algorithm -Unsupervised Algorithm.*	*Adaptive Fuzzy Control -Direct Adaptive Control.*	*Model Reference Neural Adaptive Control - Indirect Control*
	SLO-2	*Fuzzy Relations*	*Recurrent Network Architecture*	*Training Algorithm -Unsupervised Algorithm.*	*Adaptive Fuzzy Control -Direct Adaptive Control.*	*Model Reference Neural Adaptive Control - Direct Control*
S-5	SLO-1	*Fuzzy Implications*	*Learning In Neural Networks*	*Back Propagation Algorithm*	*Adaptive Fuzzy Control -Indirect Adaptive Control*	*Fundamentals Of Internal Model Control*
	SLO-2	*Theory Of Approximate Reasoning*	*Supervised Learning*	*Back Propagation Algorithm*	*Adaptive Fuzzy Control -Indirect Adaptive*	*Model Predictive Control*

					Control	
S-6	SLO-1	*Fuzzy Inference System*	*Learning In Neural Networks*	*Dynamic Back Propagation*	*Self-Organizing Fuzzy Control*	*MPC With NN*
	SLO-2	*Fuzzifier*	*Unsupervised Learning*	*Dynamic Back Propagation*	*SOFC Based On The Direct Lyapunov Method.*	*MPC Vs Conventional Control*
S-7	SLO-1	*Fuzzy Rule Base*	*Activation Function, Adding A Bias*	*Orthogonal Least Squares Algorithm*	*SOFC Based Hurwitz Stability Criteria.*	*MPC Features*
	SLO-2	*Fuzzy Inference Engine*	*Perceptron Learning Rule*	*OLS Learning*	*SOFC Based On Sensitivity Functions*	*MPC Control Law And Convergence*
S-8	SLO-1	*Defuzzifier*	*Back Propagation Algorithm*	*Orthogonal Least Squares And Genetic Algorithm*	*Model Based Fuzzy Control*	*Pros And Cons Of MPC*
	SLO-2	*Defuzzification Methods*	*Back Propagation Algorithm*	*Orthogonal Least Squares And Genetic Algorithm*	*Fuzzy Inverse Control.*	*Feed Forward Control.*
S-9	SLO-1	*Fuzzy Logic Controllers*	*Neural Network Controller*	*Adaptive Least Squares Learning Using Genetic Algorithm.*	*Fuzzy Model Based Predictive Control.*	*FFC With NN*
	SLO-2	*General Case Study*	*Application Of Neural Networks In Modeling, Estimation And Control*	*Adaptive Least Squares Learning Using Genetic Algorithm.*	*Fuzzy Internal Model Control*	*FFC Vs Conventional Control*

Learning Resources	1. *Yung C. Shin and ChengyingXu, "Intelligent Systems: Modeling, Optimization and Control", CRC Press, 2009.* 2. *Roland S Burns, "Advanced Control Engineering", Butterworth Heinemann, 2005.* 3. *René Jager, "Fuzzy Logic in Control", TU Delft Institutional Repository, 1995.*	4. *George William Irwin, K Warwick, Kenneth J Hunt, "Neural Network Applications in Control", The Institution of Electrical Engineers, 1995.* 5. *Ali Zilouchian, Mo Jamshidi, "Intelligent Control Systems using Soft Computing Methodologies", CRC Press, 2001.* 6. *Hung T Nguyen, Nadipuram R Prasad, Carol L Walker, Elbert A Walker, "A First Course in Fuzzy and Neural Control", Chapman and Hall, CRC, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)				Final Examination (50% weightage)
		CLA – 1 (20%)	CLA – 2 (30%)	CLA – 3 (30%)	CLA – 4 (20%)#	
		Theory	Theory	Theory	Theory	Theory
Level 1	Remember Understand	*40 %*	*30 %*	*30 %*	*20 %*	*30 %*
Level 2	Apply Analyze	*40 %*	*40 %*	*40 %*	*40 %*	*40 %*
Level 3	Evaluate Create	*20 %*	*30 %*	*30 %*	*40 %*	*30 %*
	Total	100 %	100 %	100 %	100 %	-

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE420T	Course Name	INTELLIGENT MECHATRONICS SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	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 different types intelligent mechatronics
CLR-2 :	Analyze the biological foundation used in intelligent systems
CLR-3 :	Identify the modeling technique of intelligent mechatronics system using bond graph
CLR-4 :	Identify the intelligent system applied into robots
CLR-5 :	Identify the intelligent system applied to automobiles
CLR-6 :	Utilize the knowledge of artificial intelligence, neural network, bond graph modeling into developing and controlling of mechatronics system.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	Identify the different types of intelligent mechatronics system	1	85	80	H	L	-	H	M	-	L	L	M	-	-	-	M	-	-
CLO-2 :	Apply the knowledge of artificial intelligent, neural network and genetic algorithm in to mechatronics system	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-3 :	Apply the bond graph modeling technique for intelligent mechatronics system	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-4 :	Apply the intelligent control into robotics application	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-5 :	Apply the intelligent control into automobile application	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-
CLO-6 :	Apply the artificial intelligence, neural network, bond graph modeling into developing and controlling of mechatronics system.	2	85	80	H	H	-	H	M	-	L	L	M	-	-	-	-	-	-

		Introduction to Intelligent Mechatronics Systems	Biological Foundations to Intelligent Systems	Bond graph modeling of Mechatronics	Case Studies - I	Case Studies - II
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Design of a mechatronics system	Artificial Neural Networks: Introduction	Bond graph for modeling, control and diagnostic	Introduction: Automatically evaluating the training of the laparoscopic surgeon	Introduction: Rail bound mechatronics systems.
	SLO-2	Autonomous supervisory control	AI programming vs conventional programming	Power variable, energy variable	Development of three-dimensional registration system, user interface	Hybrid planning for self-optimization
S-2	SLO-1	Intelligent mechatronics device	Knowledge acquisition and knowledge representation	Pseudo bond graph, analogy of energy variable	Calibration of the mechatronics evaluation system	Active suspension system
	SLO-2	Hierarchical architecture	Back - propagation networks	Bond graph elements: passive, active and junctions, two port elements	Automatic evaluation of laparoscopic training, discussion.	Air Gap Adjustment System (AGAS)
S-3	SLO-1	System structure of intelligent mechatronics	Radial basis function networks	Causality: sequential causality assignment procedure(SCAP), Bicasual bond graph	Artificial intelligence for an automatic robotic excavator	Overview of the hybrid planning architecture.
	SLO-2	Introduction to Network intelligent mechatronics	Implementation of neural network	Casual path: Types	Development of low cost electromyographyhy(EMG)prosthetic hand: background	Modeling and optimization of the suspension system
S-4	SLO-1	Structure of Network intelligent mechatronics	Fuzzy logic: Fuzzy set and membership functions.	State space equation, state equation, properties of sate variable	Mechanical design and modeling	Modeling for air gap adjustment and prediction.
	SLO-2	Introduction to Cognitive intelligent	Knowledge representation and inference	State space equation of an electrical	Electronic design ,control and actuators	Modeling for air gap adjustment and

		mechatronics	*mechanism.*	*system*		*prediction.*
S-5	SLO-1	*Structure of Cognitive intelligent mechatronics.*	*Fuzzy reasoning and control*	*Bond graph for electrical system*	*Robust monitoring of an omnidirectional mobile robot: introduction*	*Automatic transmission system*
	SLO-2	*Introduction to Communicative intelligent mechatronics*	*Developing a fuzzy system*	*Bond graph for mechanical system*	*Bond graph modeling, fault detection and isolation using bond graph*	*Concept of Hybrid electric vehicles*
S-6	SLO-1	*Structure and operation of Communicative intelligent mechatronics*	*Fuzzy neural systems: Feed forward network*	*Bond graph for milti energy domain system*	*Residual evaluation, application and conclusion*	*Concept of High speed tilting trains*
	SLO-2	*Introduction to Biological intelligent mechatronics*	*Feedback neural networks*	*Multi-port field element: RS element*	*Dynamic modeling and control of an hexapod robot: Introduction*	*Concept of Path planning robot*
S-7	SLO-1	*Structure and operation of Biological intelligent mechatronics.*	*Genetic algorithm and traditional search methods*	*C field, I field, IC field*	*Geometric modeling, hexapod dynamic model, force distribution problem*	*Introduction to Intelligent autonomous vehicle ,definition and problem formulation*
	SLO-2	*Introduction to Human assistive intelligent mechatronics*	*Genetic algorithm: Data analysis and prediction*	*R field and vector junction*	*Quadratic problem formulation and solution*	*Model based fault detection and isolation for electric vehicle*
S-8	SLO-1	*Structure and operation of Human assistive intelligent mechatronics.*	*Implementation of genetic algorithm*	*Vector bond graph for rigid body dynamics*	*Computed torque control and conclusion*	*Results of the co-simulations and conclusion*
	SLO-2	*Fault ,failure, safety and fault tolerance*	*Implementation of genetic algorithm*	*Bond graph modeling of uncertain systems*	*Control of free and constrained motion of a C5 parallel robot, adaptive position and force controller design*	*Vehicle braking ,brake system model*
S-9	SLO-1	*Signal conditioning and interfacing*	*Hybrid genetic algorithm: Lamarckian evaluation, memetic algorithm*	*Bond graph for modeling, control and diagnostic*	*Mode control for unmanned aerial vehicle*	*Regenerative braking,4 wheel vehicle model and conclusion*
	SLO-2	*Signal conditioning and interfacing*	*Hybrid genetic algorithm: Lamarckian evaluation, memetic algorithm*	*Power variable, energy variable*	*Mode control for unmanned aerial vehicle*	*Regenerative braking,4 wheel vehicle model and conclusion*

Learning Resources	1. *BodganWilamowski, J. David Irwin, "Control and Mechatronics", 2nd edition, CRC press, 2008.* 2. *Stanislaw H. Zak, "Systems and Control", Oxford University Press, 2003* 3. *Ganesh Naik, "Intelligent Mechatronics", Intech publication, 2016*	4. *Kevin M. Passino and Stephen Yurkovich, "Fuzzy Control", Addison Wesley Longman publication, 2001* 5. *Timothy J.Ross, "Fuzzy Logic with Engineering Applications", 2nd edition, John Wiley and sons, 2008* 6. *RochdiMerzouki" Mechatronic & Innovative Applications"Bentham books,2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
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Course	18MHE421T	Course	AUTONOMOUS MOBILE ROBOTICS	Course	E	*Professional Elective*	L	T	P	C

Code		Name		Category			3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Formulate the challenges in developing autonomous mobile robots*
CLR-2 :	*Abstract kinematic control of wheeled mobile robots*
CLR-3 :	*Understand the challenges involved in sensory perception for mobile robots*
CLR-4 :	*Understand the localization and path planning algorithms*
CLR-5 :	*Comprehend the challenges and configurations of aerial and underwater mobile robots*
CLR-6 :	*Build the foundations of mobile robots in various modalities*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Formulate the challenges in developing autonomous mobile robots*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-2 :	*Abstract kinematic control of wheeled mobile robots*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-3 :	*Understand the challenges involved in sensory perception for mobile robots*	*2*	*70*	*65*	*H*	*M*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-4 :	*Develop localization and path planning algorithm for mobile robot navigation*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-5 :	*Comprehend the challenges and configurations of legged, aerial and underwater mobile robots.*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-6 :	*Build the required foundation for developing autonomous mobile robots.*	*2*	*80*	*75*	*H*	*M-*	*M*	*M*	*M*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*

		Introduction	Kinematics and Control of Mobile Robots	Sensors for Mobile Robots	Localization and Path Planning	Aerial and Underwater Robots
Duration (hour)		6	10	9	10	10
S-1	SLO-1	*Mobile Robots vs. Manipulators*	*Kinematic constraints of a fixed standard wheel*	*Sensors for mobile robots*	*Introduction to localization*	*Non-ground modality*
	SLO-2	*Introduction to autonomous mobile robots*	*Derivation*	*Definitions, classification*	*Localization challenges*	*Case studies*
S-2	SLO-1	*Locomotion aspects of mobile robots*	*Kinematic constraints of a omni-directional wheel*	*Characteristics applicable to mobile robots*	*Belief representations*	*Aerial robots*
	SLO-2	*Locomotion aspects of mobile robots*	*Derivation*	*Relating the characteristics to performance attributes of mobile robot*	*Considerations in Belief representations*	*Types and comparison*
S-3	SLO-1	*Introduction to wheeled mobile robots*	*Forward kinematic models of three wheeled differential drive robot*	*Physical and computational attributes of sensors applicable to mobile robots*	*Map representations*	*Multi-rotor aerial robot*
	SLO-2	*wheel types*	*Derivation*	*sensor noise and sensor aliasing*	*Types*	*Types and applications*
S-4	SLO-1	*Wheeled Configurations*	*Forward kinematics of a three wheeled omni-directional robot*	*GPS and heading sensors*	*Probabilistic localization*	*Quadrotor aerial robot*
	SLO-2	*Various wheeled configurations*	*Derivation*	*Principles, challenges and interpretation*	*Markov localization*	*Modelling of dynamics*
S-5	SLO-1	*Maneuverability, controllability*	*Degree of freedom, differential degrees of freedom*	*Light and sound based ranging*	*Introduction to Kalman filtering*	*Modelling of flight controller*
	SLO-2	*stability of mobile robots*	*Degree of Maneuverability*	*Principles, challenges and interpretation*	*Derivation of Kalman gain*	*Derivation*
S-6	SLO-1	*Wheeled Locomotion*	*Mobility analysis of various wheeled*	*Wheel Odometry*	*Kalman filter for localization*	*Commercial flight controllers*

			configurations			
	SLO-2	Case studies	Two, three, four, five and six wheeled configurations	Implementation algorithm for wheel odomoetry	Example case study and derivation	Specifications and selection criteria
S-7	SLO-1		Workspace and trajectory considerations	Wheel Odometry Critical Analysis	Sensor fusion using Kalman filter	Underwater vehicles
	SLO-2		Comparison of manuerability and controllability	Wheel Odometry error reduction	Derivation	Foundations topics and challenges
S-8	SLO-1		State space modelling of three wheeled differential drive robot	Vision for mobile robots	Introduction to path planning,	Types of underwater vehicles
	SLO-2		Derivation	Introduction to Visual Odometry and V-SLAM	Types, Challenges and Algorithms	Comparison
S-9	SLO-1		Go-goal controller	Multi-sensor combinations	D* Lite	Modelling of underwater dynamics
	SLO-2		Block diagram level understanding	Need and types	Numerical case study	Derivation
S-10	SLO-1		Cruise Controllers		Bug algorithms	Modelling of underwater vehicle
	SLO-2		Block diagram level understanding		Vector field histogram	Derivation

Learning Resources	1. Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011. 2. Bruno Siciliano, OussamaKhatib, "Handbook of Robotics", 2nd Edition, Springer, 2016. 3. PerterCorke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	30 %	-	30 %	-	30 %	-	20 %	-	40%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	30%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	40 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE422T	Course Name	CONDITION MONITORING TECHNIQUES	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the basics of failures of equipments*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLR-2 :	*Impart the knowledge on the learning in fault diagnosis*																		
CLR-3 :	*Gain knowledge on the condition monitoring techniques*																		
CLR-4 :	*Impart the knowledge on condition monitoring of rotating electrical machines*																		
CLR-5 :	*Impart the knowledge on condition monitoring of machine tools*																		
CLR-6 :	*Study the basic knowledge of failures of equipments and knowledge on condition monitoring of different machine tools*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Comprehend the basics of failures of equipments*	*1*	*85*	*80*	*H*	*L*	*-*	*M*	*-*	*-*	-	-	-	-	-	-	-	-	-
CLO-2 :	*Understand the learning in fault diagnosis*	*1*	*85*	*80*	*H*	*L*	*-*	*M*	*-*	*-*	-	-	-	-	-	-	-	-	-
CLO-3 :	*Familiarize with the condition monitoring techniques*	*1*	*85*	*80*	*H*	*L*	*-*	*M*	*L*	*-*	-	-	-	-	-	-	*M*	*H*	*H*
CLO-4 :	*Implement the condition monitoring techniques on rotating electrical machines*	*2*	*85*	*80*	*H*	*L*	*-*	*M*	*L*	*-*	-	-	-	-	-	-	*M*	*H*	*H*
CLO-5 :	*Implement the condition monitoring techniques on machine tools*	*2*	*85*	*80*	*H*	*L*	*-*	*M*	*L*	*-*	-	-	-	-	-	-	*M*	*H*	*H*
CLO-6 :	*To understand the diagnostics techniques of different machine tools*	*2*	*85*	*80*	*H*	*L*	*-*	*M*	*L*	*-*	-	-	-	-	-	-	*M*	*H*	*H*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to condition monitoring*	*Condition monitoring of electrical machines - Introduction*	*Condition monitoring in machine tool - Introduction*	*Condition monitoring techniques for hydraulic system – introduction*	*Case study 1: Fault detection on gearboxes operating under fluctuating load con*
	SLO-2	*Theory of condition monitoring*	*Construction of electrical machines*	*Types of cutting tool in lathe*	*Elements in hydraulic systems*	*Bearing Fault diagnosis in gear box*
S-2	SLO-1	*Stages of condition monitoring*	*Structure of electrical machines and types*	*Tool wear measurement techniques – Direct method*	*Pump supervision methods and fault detection techniques*	*Case study 2: Detection of rotor – Stator rubbing in rotating machinery using acoustic emissions*
	SLO-2	*Data used for condition monitoring – Time, model and frequency domain*	*Types of insulation ageing mechanism – Thermal and electrical ageing*	*Tool wear measurement techniques – Indirect method*	*Fault detection of centrifugal pumps with vibration sensors*	*Condition monitoring of very slowly rotating machinery using AE techniques*
S-3	SLO-1	*Data processing techniques for condition monitoring*	*Types of insulation ageing mechanism – Mechanical and environmental ageing*	*Types of machine tool failures*	*Types failures in reciprocating pump*	*Case study 3: Condition monitoring for a car engine*
	SLO-2	*Data acquisition system – filter, data logging system*	*Condition monitoring techniques: Visual monitoring.*	*Fault detection and diagnosis of machine tool*	*Fault diagnosis in reciprocating pumps*	*Application of vibration diagnostics and suppression in automobile*
S-4	SLO-1	*Condition monitoring methods – vibration analysis, Thermography*	*Failure modes in electrical machines – Stator core and rotor winding failure*	*Vision based tool condition monitoring system*	*Leak detection methods in fluid power pipe line*	*Case study 4; Condition monitoring of a hydraulic system using neural networks*
	SLO-2	*Condition monitoring methods – Oil Analysis, Performance analysis*	*Failure modes in electrical machines – Electrical connection and bearing failures*	*Decision making for sensor based tool condition monitoring system*	*Leak detection with mass balance for liquid pipe line*	*Multi-layer neural networks and pattern recognition for pump fault diagnosis*
S-5	SLO-1	*Instruments for condition monitoring – Displacement and velocity measurement*	*Electrical machines temperature monitoring*	*Online tool vibration monitoring system*	*Types of failures in fluid power linear actuators*	*Case study 5: Non-destructive fault induction in an electro-hydraulic servo system*

	SLO-2	Instruments for condition monitoring – Force and noise measurement	Electrical machines wear debris monitoring	Online tool wear monitoring system	Fault detection and diagnosis of cylinder	Failure analysis and fault simulation of an electro hydraulic servo valve
S-6	SLO-1	Instruments for condition monitoring – Temperature measurement	Electrical machines lubrication oil monitoring	Introduction to grinding process and its types	Types of failures in pneumatic and hydraulic Directional control valves	Case study 6; Monitoring exhaust valve leaks in diesel engines
	SLO-2	Instruments for condition monitoring – current and Chemical composition measurement	Electrical machines vibration monitoring	Introduction to milling process and its types	Fault detection and diagnosis of pneumatic and hydraulic Directional control valves	Monitoring vibration in diesel engines
S-7	SLO-1	Laser based measurement systems for condition monitoring	Fault detection in electrical machines – stator winding fault detection	Acoustic Emission based Monitoring of Grinding Wheel Dressing	Fault detection and diagnosis of flow control valves with pneumatic position controller	Case study 7: Development of an automated fluorescent dye penetrant inspection system
	SLO-2	Ultrasonic sound based measurement systems for condition monitoring	Fault detection in electrical machines – Brush gear fault detection	Acoustic Emission based Monitoring of Face milling	Fault detection and diagnosis of flow control valves with electronic position controller	Application of vibration analysis to monitor wear in spur gear
S-8	SLO-1	Types of Maintenance – Preventive, operative and shutdown maintenance	Fault detection in electrical machines – rotor online fault detection	Diagnostics techniques for bearing condition monitoring in machine tool	Types of failures in electro pneumatic actuator	Case study 8: On-line acoustic viscometry in oil condition monitoring
	SLO-2	Condition based maintenance	Fault detection in electrical machines – rotor offline fault detection	Sensors and signal processing techniques for bearing condition monitoring system	Fault detection and diagnosis of electro pneumatic actuator	On-line vibration monitoring for detecting fan blade damage
S-9	SLO-1	Diagnostics process and Techniques	Discharge monitoring techniques – RF coupling method	Condition monitoring techniques for sheet metal process	Real time oil oxidation monitoring system	Case study 9: A case study of bearing condition monitoring using Shock pulse method
	SLO-2	Diagnostics process and Techniques	Discharge monitoring techniques – capacitive coupling method	Remote CNC machine control	Oil viscosity monitoring system	Remote online condition monitoring for wear measurement in bearing

Learning Resources	1. Peter Tavner, Li Ran, Jim Penman, Howard Sedding, Condition monitoring of rotating electrical machines, 1st ed., The Institution of Engineering and Technology, London, 2008 2. LihuiWang and Robert X. Gao., Condition Monitoring and Control for Intelligent Manufacturing,1st ed., Springer-Verlag London Limited, 2006	3. Rolf Isermann, Sensors, and Fault-tolerant Systems, 1st ed., Springer Heidelberg Dordrecht London New York, 2011 4. Andrew C Starr and Raj B K N Rao., Condition monitoring and diagnostic engineering management, Proceedings of the 14'" international Congress, 4 - 6 September Manchester, UK, 2001

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE423T	Course Name	FPGA BASED SYSTEM DESIGN	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	18MHC108J	Co-requisite Course	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 types of PLDs and their differing architectures
CLR-2 :	Discuss different software and hardware programming language, simulation tools
CLR-3 :	Gain knowledge about VHDL, its design flow and various description languages for Digital Logic Design
CLR-4 :	Design combinational logic, sequential logic and state machine using VHDL
CLR-5 :	Gain knowledge of VHDL design at system level and transformation of design developed in Matlab to VHDL
CLR-6 :	Introduce about PLDs and developing digital logic design using VHDL code for electronic system design

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	Acquire knowledge about various Programmable Logic Devices to design an electronic system	1	75	70	H	M	M	M	M	L	L	L	M	M	M	H	H	H	M
CLO-2 :	Understand programming languages to develop digital design for implementation either in processors or in PLDs	2	75	70	H	M	M	H	H	L	L	L	M	M	M	H	H	H	L
CLO-3 :	Utilize the various description languages for developing various digital logic design	2	75	70	H	M	M	H	H	L	L	L	M	M	M	H	H	M	L
CLO-4 :	Develop VHDL code for Combinational logic, sequential logic and state machine design	3	75	70	H	H	M	H	H	L	L	L	M	M	M	H	H	H	L
CLO-5 :	Translate algorithms and models developed in MATLAB Simulink into VHDL for implementing in PLD	3	75	70	H	H	M	H	H	L	L	L	M	M	M	H	H	M	L
CLO-6 :	Design and develop VHDL code for implementation of digital logic in PLDs	3	75	70	H	H	M	H	H	L	L	L	M	M	H	H	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to PLD's	Introduction to various software programming languages: C	Designing with Hardware description language	Introduction to combinational logic design	Digital to Analogue Conversion (DAC)
	SLO-2	Technology choices for digital circuit design	C++, Java	Various levels of design description	VHDL design for half adder	Digital to Analogue Conversion (DAC)
S-2	SLO-1	Electronic circuits: Analogue versus Digital	Introduction to various software programming languages: Visual Basics	Typical design flow using HDLs	Concept of multiplexer	VHDL Design for DAC
	SLO-2	Digital logic and its types	Scripting Languages, PHP	Typical design flow using HDLs	VHDL design for multiplexer	VHDL Design for DAC
S-3	SLO-1	Programmable Logic versus Digital Logic	Introduction to hardware programming languages	Design Entry Methods, HDL Design Entry	Concept of Encoder	Concept of Thyristor Gate Control
	SLO-2	Programmable Logic versus Processors	Types of hardware programming languages	Logic Synthesis with an example	VHDL design for Encoder	Concept of Thyristor Gate Control
S-4	SLO-1	Types of PLD: Simple Programmable Logic Device (SPLD)	VHDL hardware programming language	Entities, architectures, packages and configurations	Introduction to Sequential Logic Design	VHDL Design for Thyristor Gate Control
	SLO-2	Complex Programmable Logic Device (CPLD)	VHDL description for two input AND gate	Two input AND gate example	VHDL design for D-Latch	VHDL Design for Thyristor Gate Control
S-5	SLO-1	Field Programmable Gate Array (FPGA)	Verilog HDL hardware programming language	Key libraries and packages in HDL	Design of binary counter using VHDL	Model of DC Motor Control System
	SLO-2	FPGA design techniques and design	Verilog HDL description for full adder	Various operators in VHDL	Design of binary counter using VHDL	Model of DC Motor Control System

		constraints				
S-6	SLO-1	*PLD configuration technologies*	*Verilog-A hardware programming language*	*Dataflow description with example*	*Introduction to State Machine Design*	*Translation of DC motor Control system Design to VHDL*
	SLO-2	*PLD vendors*	*Verilog-A description for voltage amplifier*	*Dataflow description with example*	*Introduction to State Machine Design*	*Translation of DC motor Control system Design to VHDL*
S-7	SLO-1	*PLD design tools*	*System Verilog*	*Behavioral description with example*	*VHDL Design for Sequence Detector*	*Overview of Digital Filter Design*
	SLO-2	*Common basic features of design tools*	*Simulation Program with Integrated Circuit Emphasis (SPICE)*	*Behavioral description with example*	*VHDL Design for Sequence Detector*	*Overview of Digital Filter Design*
S-8	SLO-1	*Introduction to PLD design*	*Introduction to mathematical modeling*	*Structural description with example*	*VHDL design for UART receiver*	*Translation of Digital Filter Design to VHDL*
	SLO-2	*Typical PLD design flow*	*Various toolboxes for modeling different applications*	*Structural description with example*	*VHDL design for UART receiver*	*Translation of Digital Filter Design to VHDL*
S-9	SLO-1	*Technology Trends*	*Concept of Motor control system*	*Coding styles for VHDL*	*Testing of VHDL Design*	*Automation of Design translation to VHDL*
	SLO-2	*Technology Trends*	*Modeling of motor control system using Simulink*	*Coding styles for VHDL*	*Testing of VHDL Design*	*Automation of Design translation to VHDL*

Learning Resources	1. *Ian Grout, "Digital System Design with FPGA and CPLD", Newnes publishers, 2nd edition, 2008.* 2. *Peter Wilson, "Design Recipes for FPGAs", Newnes publishers, 3rd edition, 2007.*	3. *Wayne Wolf, "FPGA based system design", Prentice Hall, 1st edition, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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2.Mr. N.Srikanth, Lekha Wireless Solutions, Banglore, srikanth05.mit@gmail.com	*2.Dr.M.Devanathan, REVA University, devanathan.m@reva.edu.in*	*2. Mr. K.Sivanathan, SRMIST*

Course Code	18MHE424T	Course Name	DESIGN AND ANALYSIS OF ALGORITHMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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 and apply algorithm analysis technique*
CLR-2 :	*Describe computational solution to well known problems like searching, sorting etc.*
CLR-3 :	*Understand various approaches to solve greedy and dynamic algorithms*
CLR-4 :	*Utilize back tracking and branch and bound paradigms to solve exponential time problems*
CLR-5 :	*Analyze various algorithm design techniques to solve real time problems in polynomial time*
CLR-6 :	*Understand the limitations of Algorithmic power*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Design algorithms for various computing problems*	3	80	70	L	H	-	H	L	-	-	-	L	L	-	H	-	-	-
CLO-2 :	*Estimate the computational complexity of different algorithms*	3	85	75	M	H	L	M	L	-	-	-	M	L	-	H	-	-	-
CLO-3 :	*Critically analyze the different algorithm design techniques for a given problem*	3	75	70	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-4 :	*Modify existing algorithm to improve efficiency*	3	85	80	M	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-5 :	*Develop an algorithm using appropriate design strategies for problem solving*	3	85	75	H	H	M	H	L	-	-	-	M	L	-	H	-	-	-
CLO-6 :	*Create algorithms that are efficient in space and time complexities by using divide conquer, greedy, backtracking techniques*	3	80	70	L	H	M	H	L	-	-	-	L	L	-	H	-	-	-

		Introduction	Divide and conquer	Greedy Method	Dynamic Programming	Backtracking
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction: What is an Algorithm?*	*Divide and Conquer: General method*	*Greedy Method: General method*	*Dynamic Programming: General method*	*Backtracking: General method*
	SLO-2	*Algorithm Specification*	*Binary Search*	*Examples*	*Examples*	*N-Queens problem*
S-2	SLO-1	*Analysis Framework*	*Complexity of Binary search*	*Coin Change Problem*	*Multistage Graphs*	*Sum of subsets problem*
	SLO-2	*Performance Analysis: Space complexity*	*Recurrence equation for divide and conquer*	*Knapsack Problem using Greedy method*	*Graph algorithms*	*Graph coloring*
S-3	SLO-1	*Performance Analysis: Time complexity*	*Finding the maximum and minimum*	*Job sequencing with deadlines*	*Transitive Closure: All Pairs*	*Hamiltonian cycles*
	SLO-2	*Asymptotic Notations: Big-Oh notation (O)*	*Time complexity analysis-Examples*	*Minimum cost spanning trees*	*Dynamic programming-Longest ascending subsequence*	*Branch and Bound: Assignment Problem*
S-4	SLO-1	*Asymptotic Notations: Omega notation (Ω)*	*Algorithm for finding closest pair problem*	*Prim's Algorithm with example*	*Dynamic programming-Memorization*	*Travelling Sales Person problem-Backtracking*
	SLO-2	*Asymptotic Notations: Theta notation (Θ)*	*Merge sort algorithm*	*Kruskal's Algorithm*	*Dynamic programming-Matrix Multiplication*	*0/1Knapsack problem-Backtracking*
S-5	SLO-1	*Mathematical analysis of Non-Recursive Algorithms*	*Complexity Analysis of Merge sort*	*Example problem*	*Transitive Closure: Warshall's Algorithm*	*LC Branch and Bound solution*
	SLO-2	*Examples*	*Quick sort algorithm*	*Single source shortest paths: Dijkstra's Algorithm*	*Shortest Paths: Floyd's Algorithm*	*FIFO Branch and Bound solution*
S-6	SLO-1	*Mathematical analysis of recursive*	*Complexity Analysis of Quick sort*	*Example problem*	*Floyd-Warshall Introduction*	*NP-Complete and NP-Hard problems:*

		Algorithms				Basic concepts
	SLO-2	Examples	Best case, Worst case and Average case analysis	Optimal Tree problem: Huffman Trees	Floyd-Warshall with sample graph	On-deterministic algorithms
S-7	SLO-1	Important Problem Types: Sorting	Strassen's matrix multiplication	Optimal Tree problem: Huffman Codes	Floyd-Warshall complexity	P type problems
	SLO-2	Searching, String processing	Recurrence Relation	Transform and Conquer Approach: Heaps	Optimal Binary Search Trees	NP type problems
S-8	SLO-1	Graph Problems, Combinatorial Problems	Advantages of divide and conquer	Transform and Conquer Approach: Heap Sort	Knapsack problem using Dynamic method	NP-Complete Problems-Introduction
	SLO-2	Fundamental Data Structures: Stacks, Queues	Disadvantages of divide and conquer	Binomial Heaps	Bellman-Ford Algorithm	Satisfiability Problem
S-9	SLO-1	Graphs, Trees	Decrease and Conquer Approach	Fibonacci Heaps	Travelling Sales Person problem-Dynamic approach	NP-Hard classes
	SLO-2	Sets and Dictionaries.	Topological Sort	Examples of heaps and heap sort	Reliability design	Examples

Learning Resources	1. AnanyLevitin, Intoduction to Design and Analysis of Algorithms, 3rd ed., Pearson, 2009 2. Ellis Horowitz, SatrajSahini and Rajasekaran, Computer Algorithms/C++, 2nded, Universities Press,2014	3. Thomas H .Cormen, Charles E.Leiserson, Ronal L.Rivest,Clifford Stein., Introduction to Algorithms , 3rded.,PHI 4. S Sridhar, Design and Analysis of Algorithms, Oxford(Higher Education)

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	30 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	30 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE425T	Course Name	ADVANCED MICROCONTROLLERS AND SIGNAL PROCESSORS	Course Category	P	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	18MHC205J	Co-requisite Course	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 :	Perceive the fundamental knowledge of Digital signal processing
CLR-2 :	Learn the working principle of Digital signal processor TMS320C5X
CLR-3 :	Apply the Knowledge in the applications of Digital signal processing
CLR-4 :	Know the working principle of ARM cortex processor
CLR-5 :	Work with the processor by using their standard Instruction sets
CLR-6 :	Perceive the fundamental knowledge of Digital signal processing

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	Acquire the fundamental knowledge of Digital signal processing	1	90	85	H	L	L	L	L	L	L	L	L	L	L	L	M	L	L
CLO-2 :	Learn the working principle of Digital signal processor TMS320C5X	1	90	80	H	L	L	L	L	L	L	L	L	L	L	L	M	M	L
CLO-3 :	Apply the Knowledge in the applications of Digital signal processing	2	85	80	H	M	M	M	M	L	L	L	M	L	M	M	M	H	M
CLO-4 :	Learn the working principle of ARM cortex processor	2	90	85	H	L	L	L	L	L	L	L	L	L	L	L	M	M	M
CLO-5 :	Have knowledge to Work with the processor by using their standard Instruction set	3	85	80	H	M	M	M	M	L	L	L	L	L	L	L	H	H	H
CLO-6 :	Gain knowledge about different applications using ARM and DSP controllers	3	85	80	H	H	H	H	H	L	L	L	M	L	L	M	M	H	H

		Introduction	DFT and its applications	DSP Processor	ARM Cortex Processor	System Design – Case Study
Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to Micro- controller based system design	Discrete Fourier Transform(DFT) and its properties	Introduction to DSP processors	Introduction to ARM processors	Comparison chart of various controllers
	SLO-2	Issues and challenges.	Signal conditioning system	Types of DSP processors	Types of ARM processor	Parameter selection of Controllers
S-2	SLO-1	Van-New-Mann architecture	Fast Fourier Transform(FFT) and its properties	Architecture: Block diagram of DSP processor TMS320C5X	Block diagram of ARM architecture	Analog to Digital conversion: Flash ADC
	SLO-2	Mechatronics design elements	Fast Fourier Transform(FFT) and its properties	Architecture DSP processor TMS320C5X	Block diagram of ARM architecture	Analog to Digital conversion: Successive approximation
S-3	SLO-1	Harvard architecture	DIT-FFT	Instruction set of DSP processor TMS320C5X	ARM organization : 3 stage	Digital to Analog conversion working principle
	SLO-2	Modified Harvard architecture	Problems based on DIT-FFT	Arithmetic Instructions	ARM organization : 5 stage	Types of DAC
S-4	SLO-1	RISC, CISC	DIF-FF	Logical instructions	ARM instruction set	Power convertors
	SLO-2	ASIP, Superscalar, VLIW	Problems based on DIF-FF	Load instructions	Data processing & Data transfer instructions	Power convertor applications
S-5	SLO-1	Superscalar architecture of Pentium	FIR Digital filter design	Multiply/Accumulate (MAC) operation	Multiply instruction	Power inverters
	SLO-2	Superscalar architecture of Pentium multicore processors	Problems based on FIR Digital filter design	Branching Instructions	Co processor instructions	Power inverter application
S-6	SLO-1	Types of Discrete time signals	IIR digital filter design	Compare, Select, and Store Unit (CSSU)	Addressing modes of ARM processor	Temperature sensors and its types

	SLO-2	*Properties of Discrete time signals*	*Problems based on IIR digital filter design*	*Construction and operation of BLDC motor*	*Input and Output Modules, Mnemonics for programming*	*Temperature sensor applications*
S-7	SLO-1	*Principles of Digital Signal Processing (DSP)*	*Direct form-I structure for FIR and IIR systems*	*Addressing modes of DSP processor TMS320C5X*	*Thumb instruction set*	*Stepper motor control using DSP processor*
	SLO-2	*Sampling*	*Problems*	*Pressure control valve*	*Comparison of Thump and ARM instruction set*	*Stepper motor control using ARM processor*
S-8	SLO-1	*Convolution of discrete-time samples*	*Direct form-II structure for FIR and IIR systems*	*Writing optimized DSP codes*	*Writing optimized ARM codes*	*DC machine control using DSP processor*
	SLO-2	*Properties of Convolution*	*Problems*	*Writing optimized DSP codes*	*Writing optimized ARM codes*	*DC machine control using ARM processor*
S-9	SLO-1	*Correlation of discrete-time samples*	*Cascade structure for FIR and IIR systems*	*Simple programs using DSP codes*	*Basic ARM assembly language programs*	*AC machine control using DSP processor*
	SLO-2	*Properties of Correlation*	*Problems*	*Kinematic chains, Cams actuation with example, Gear trains with example*	*Basic ARM assembly language programs*	*AC machine control using ARM processor*

Learning Resources	1. *Steve Furber, "ARM System-on-chip Architecture", Pearson Education, India, 2000.* 2. *Joseph Yiu, "The Definitive Guide to ARM Cortex Processors", 3rd edition, Newnes Publication, 2013*	3. *John G Proakis and Dimitris G Manolakis, "Digital Signal Processing- Principles, Algorithms and Applications", 4th edition, Prentice Hall of India Limited, 2007.* 4. *M Bhaskar and B Venkataramani, "Digital Signal Processors: Architecture, Programming and Application", 2nd Edition, Mcgraw Higher Ed, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*40 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*20 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Ragavendrarao, Hardware Architect,, Intel technology Pvt. Ltd, Bangalore, ragavendra.r.r@intel.com	*1. Dr. Priestly Shan, Dean, School of Electrical, Electronics and Communication Engineering, Galgotias University, New Delhi, dean.seece@galgotiasuniversity.edu.in.*	*1. Ms. Cross T. Asha Wise, SRMIST*
2. Dr.K.Kathikeyan,R&DSpecialist,ABB India Ltd., Bangalore, India, sayalkarthik@yahoo.co.in	*2. Dr. DivyaC.,Professor, Centre for Information Technology and Engineering, ManonmaniamSundaranar university, Thirunelveli, cdivya@msuniv.ac.in*	*2. Ms. Sasikala D., SRMIST*

Course Code	18MHE426T	Course Name	ROBOT KINEMATICS AND DYNAMICS	Course Category	E	*Professional Elective*	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*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 complexity and method of solving inverse kinematics for an manipulator robot*
CLR-2 :	*Understand the concept of jacobian and singularity for manipulator*
CLR-3 :	*Understand and solve dynamics problem for the manipulator*
CLR-4 :	*Understand the various position and force control scheme and architecture*
CLR-5 :	*Understand the parallel configuration of robot*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Solve the inverse kinematics problem for the various configuration of serial manipulator*	2	80	70	H	H	L	L	-	-	-	-	-	-	L	H	H	M	-
CLO-2 :	*Compute the Jacobian matrix and singularity points for a manipulator robot*	2	80	70	H	H	L	M	-	-	-	-	M	L	-	H	H	M	-
CLO-3 :	*Compute the dynamic model of a serial manipulator*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-
CLO-4 :	*Understand the mathematical concept of various control schemes used for manipulator robots*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-
CLO-5 :	*Understand the parallel configuration of robot*	2	80	70	H	H	L	M	-	-	-	-	M	-	-	H	H	M	-

		Forward and Inverse Kinematics	Manipulator Jacobian and Singularity	Dynamics	Position and force control	Parallel Manipulator
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Forward Kinematics of 6 DOF articulated arm*	*Description/Notation for time varying position and orientation*	*Introduction to dynamics*	*Review of position control*	*Introduction to Parallel Manipulators*
	SLO-2	*Forward Kinematics of 6 DOF articulated arm*	*Example*	*Inertia, Centrifugal force, coriolis force etc*	*Control of Mass- spring damper system*	*Comparison with serial and parallel manipulator*
S-2	SLO-1	*Forward Kinematics of a Stanford Manipulator*	*Linear velocity vector for rigid bodies*	*Understanding dynamics of a simple system- mass spring damper system*	*Modelling of 1 DOF manipulator Joint*	*Various configuration of Parallel manipulator*
	SLO-2	*Forward Kinematics of a Stanford Manipulator*	*Angular velocity vector for rigid bodies*	*Inverse and forward dynamics*	*Deriving the mathematical model*	*Degree of freedom computation of parallel manipulator*
S-3	SLO-1	*Inverse Kinematics Introduction*	*Manipulator Jacobian*	*Lagrangian Formulation*	*Partitioned PD (PPD)control scheme*	*Forward and Inverse kinamtics of a parallel manipulator*
	SLO-2	*Issues in Inverse Kinematics*	*Importance of Jacobain matrix*	*Computing generalized torque/force through Lagrangian Euler method*	*Architecture and difference from PD control*	*Difficulty in forward kinematics*
S-4	SLO-1	*Algebraic and geometric method for RRR manipulator*	*Linear Velocity Jacobian*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Introduction to force control*	*Inverse Kinematics of a planar parallel manipulator*
	SLO-2	*Algebraic and geometric method for RRR manipulator*	*Derivation for RR planar manipulator*	*Dynamic model of a 2 R Planar manipulator using LE method*	*Application of force control*	*Inverse Kinematics of a planar parallel manipulator*
S-5	SLO-1	*Inverse Kinematics Computation- Closed*	*Linear and angular velocity Jacobian*	*Newton Euler Formulation*	*Frame work for force /position control*	*Inverse Kinematics of a spatial parallel*

		loop solution	Computation		scheme	manipulator
	SLO-2	Case study- spherical wrist	Linear and angular velocity Jacobian Computation	Computing generalized torque/force through Newton Euler method	Define- Artificial and natural constraints	Inverse Kinematics of a spatial parallel manipulator
S-6	SLO-1	Inverse kinematics of articulated arm (3 DOF)	Concept of Singularity	Dynamic model of a 2 R Planar manipulator using LE method	Case study to define artificial and natural constraint	Velocity analysis
	SLO-2	Inverse kinematics of articulated arm (3 DOF)	Types and Consequences	Dynamic model of a 2 R Planar manipulator using LE method	Case study to define artificial and natural constraint	Jacobian computation
S-7	SLO-1	Inverse kinematics of Stanford manipulator	Singularity Computation using Jacobian	Dynamic model of a inverted pendulum	Description of force control task	Workspace analysis
	SLO-2	Inverse kinematics of Stanford manipulator	Example using RR Manipulator	Dynamic model of a inverted pendulum	Example- Peg in hole assembly	Example
S-8	SLO-1	Computation consideration for inverse kinematics	Jacobian Computation for RPY wrist	Dynamic model of a SCARA robot	Force control of mass spring system	
	SLO-2	Example	Singularity Computation for RPY wrist	Dynamic model of a SCARA robot	Force control of mass spring system	
S-9	SLO-1		Jacobian Computation for articulated arm	Static Forces in manipulator	Dynamics based control	
	SLO-2		Singularity Computation for articulated arm	Static Forces in manipulator- Example	General dynamics representation	
S-10	SLO-1		Work space Analysis	Jacobian in force domain	Computed torque control	
	SLO-2		Work space Analysis	Derivation- Static force computation of a planar RR manipulator	Architecture	

Learning Resources	1. John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008. 2. Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008. 3. J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006. 4. Saeed B.Niku, "Introduction to Robotics Analysis, Systems and Applications", 2nd edition, Prentice Hall of India, 2009.	5. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India Learning, 2009. 6. Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007. 7. Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition McGraw Hill, 2008. 8. Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu	2. Dr.rSenthilnathan, SRMIST

Course	18MHE427T	Course Name	SYSTEMS ENGINEERING	Course	E	Professional Elective	L	T	P	C

Code				Category			3	0	0	3

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

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Gain the knowledge of systems engineering*
CLR-2 :	*Identify the need for complex systems*
CLR-3 :	*Utilize the management skills in systems engineering*
CLR-4 :	*Gain knowledge of systems analysis*
CLR-5 :	*Introduce the analysis concepts in systems engineering*
CLR-6 :	*Gain knowledge of Engineering design*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Knowledge of systems engineering*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Knowledge of systems complexity*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-3 :	*Application of the management skills in systems engineering*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-4 :	*Knowledge of systems analysis*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-5 :	*knowledge of analysis concepts*	3	75	70	H	H	M	H	M	-	-	-	-	-	-	H	M	M	M
CLO-6 :	*Interpret the knowledge of Engineering Design*	3	75	70	H	H	M	H	H	-	-	-	-	-	-	H	H	H	H

		Introduction to Systems Engineering	Complex Systems	Systems Engineering Management	Systems Analysis	Engineering Design
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Origin of Systems Engineering*	*Complex System Structure*	*Managing Systems Development*	*Need Analysis*	*Prototype Development*
	SLO-2	*Origin of Systems Engineering*	*Complex System Structure*	*Managing Systems Development*	*Need Analysis*	*Prototype Development*
S-2	SLO-1	*Examples of Systems Engineering*	*Building Blocks*	*Risks of Systems Engineering*	*Functional Analysis and Allocation*	*Development Testing and Risk Reduction*
	SLO-2	*Examples of Systems Engineering*	*Building Blocks*	*Risks of Systems Engineering*	*Functional Analysis and Allocation*	*Development Testing and Risk Reduction*
S-3	SLO-1	*Systems Engineering Field*	*Hierarchy and Interfaces*	*Work Breakdown Structure (WBS)*	*Model-Based Systems Engineering (MBSE)*	*Probability of data analysis*
	SLO-2	*Systems Engineering Field*	*Hierarchy and Interfaces*	*Work Breakdown Structure (WBS)*	*Model-Based Systems Engineering (MBSE)*	*Hypothesis testing*
S-4	SLO-1	*Systems Engineering View point*	*Complex System Interactions*	*Systems Engineering Management Plan (SEMP)*	*Requirement Analysis*	*Implementing system building blocks*
	SLO-2	*Systems Engineering View point*	*Complex System Interactions*	*Systems Engineering Management Plan (SEMP)*	*Requirement Analysis*	*Implementing system building blocks*
S-5	SLO-1	*Domain of Systems Engineering*	*System Complexity*	*Systems Risk Management*	*Decision Making*	*Reliability and Redundancy*
	SLO-2	*Domain of Systems Engineering*	*System Complexity*	*Systems Risk Management*	*Decision Making*	*Reliability and Redundancy*
S-6	SLO-1	*Approaches of Systems Engineering*	*Complex System Environment*	*Systems Architecture*	*Modeling for Decisions*	*Concepts of Maintainability, Availability and Producibility*
	SLO-2	*Approaches of Systems Engineering*	*Complex System Environment*	*Systems Architecture*	*Modeling for Decisions*	*Concepts of Maintainability, Availability and Producibility*
S-7	SLO-1	*Activities of Systems Engineering*	*Systems Engineering methods*	*Performance Requirements*	*Simulation Analysis*	*Systems Integration*
	SLO-2	*Activities of Systems Engineering*	*Systems Engineering methods*	*Performance Requirements*	*Simulation Analysis*	*Systems Integration*

S-8	SLO-1	*Perspectives of Systems Engineering*	*Life cycle and Evolutionary characteristics*	*System Requirements Development*	*System Modeling Languages*	*Testing and evaluating total system*
	SLO-2	*Perspectives of Systems Engineering*	*Life cycle and Evolutionary characteristics*	*System Requirements Development*	*System Modeling Languages*	*Testing and evaluating total system*
S-9	SLO-1	*Systems Engineering Products*	*Systems testing throughout development*	*Systems Validating Requirements*	*Trade-off Analysis*	*Development to Production*
	SLO-2	*Systems Engineering Products*	*Systems testing throughout development*	*Systems Validating Requirements*	*Trade-off Analysis*	*Development to Production*

Learning Resources	1. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", John Wiley & Sons, 2nd Edition, 2011.* 2. *Blanchard, B.S. and Fabrycky, W.J., "Systems Engineering and Analysis", Prentice Hall,4th Edition, 2005.* 3. *Zeigler, B.P., H. Praehofer, T.G. Kim., "Theory of Modeling and Simulation", Academic Press,2nd Edition, 2000.*	4. *Groover. M.P., "Automation, production systems and computer integrated manufacturing", 3rd edition, Prentice Hall of India, 2007.* 5. *Gharajedaghi, J., "Systems Thinking, Managing Chaos and Complexity: A Platform for Design Business Architecture", Butterworth Heinemann, 2nd Edition, , 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. K.P.Srinivasan, Visteon Automotive Electronics Limited, Chennai, psriniv1@visteon.com	*1. Dr. P. Karthikeyan, Anna University, Chennai, pkarthikeyan@mitindia.edu*	*1. Dr. T. Muthuramalingam, SRMIST*
2. Mr. S. EllanChezhiyan, Keyence Microscope Limited, Chennai, ellanchezhian@gmail.com	*2. Dr. D. Saravanakumar, VIT University, Chennai, saravanakumar.d@vit.ac.in.*	*2. Dr. M. Mohamed Rabik, SRMIST*

Course Code	18MHE451T	Course Name	ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	Nil	Co-requisite Course	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 various architecture of Industrial robot
CLR-2 :	Understand the concept of vectors and transformation used in robotics
CLR-3 :	Formulate the forward kinematics of manipulators
CLR-4 :	Introduce the various actuators, transmission elements and sensors used in robot
CLR-5 :	Introduce the various control strategy and work cell layout
CLR-6 :	Understand the terminologies and various mathematical concepts in manipulator robotics

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	Understand various terminologies and configuration of an industrial robot	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	Understand the application of vectors and transformation applied to robotics	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	Solve the forward kinematic model of the manipulators	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	Understand the various actuators, sensors and transmission used in robot	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	Understand the various types of control used in robot	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	Get conversant with fundamental terminologies and mathematical concepts to solve kinematics problem	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Introduction to Robotics	Transformations	Manipulator Kinematics	Introduction to sensors and actuators in robotics	Trajectory planning and work cell
Duration (hour)		9	12	11	8	8
S-1	SLO-1	Introduction to Robotics- History, laws of robotics	Review of Vectors	Introduction to kinematics	Basic Actuators	Types of Robot control
	SLO-2	Classification based on application	Vector representation of points and bodies	Forward and inverse kinematics	Selection of actuators	Cartesian and joint space scheme trajectory planning
S-2	SLO-1	Definition of work volume	Translation-numerical problem	Geometric and algebraic approach	Transmission elements	Force control
	SLO-2	Classification based on work volume	Rotation-numerical problem solving	Forward kinematics of RR,RRR planar manipulator using geometric approach	Selection	Case study- Mass Spring system
S-3	SLO-1	Precision, repeatability, accuracy in terms of robotics	Representing rotation- rotation matrix	Geometric approach for RRP spatial manipulator	Harmonic drives	Position Control
	SLO-2	Co ordinate systems and Degree of freedom	Numerical problem solving	Comparison of geometric and algebraic approach	Advantage of harmonic drives over other transmission elements	Case Study- 1 DOF joint model
S-4	SLO-1	Various joints in robot, links	Representing Rotation- Euler angles	D-H formulation for manipulator kinematics	Force sensors – Importance and types, working Principle	Hybrid force position control
	SLO-2	Configuration and operational space	Numerical problem solving	D-H formulation for manipulator kinematics	Maltese Cross Configuration	Case study
S-5	SLO-1	Anatomy of robot and wrist configuration	Representing Rotation- Equivalent axis representation	Difference between standard and modified DH convention	Tactile sensor- Importance and use	Robot Cell Layout
	SLO-2	Example	Numerical problem solving	Example – kinematics of RR planar manipulator using both convention	Tactile sensor- Various type and its working	Robot Cell Layout

S-6	SLO-1	Robot end effectors	Difference between current axis and fixed axis representation	Forward kinematics of 3 DOF RRP manipulator	Slip sensor- Importance and use	Safety Monitoring
	SLO-2	Various Types	Numerical problem solving	Forward kinematics of 3 DOF RRP manipulator	Slip sensor- Various type and its working	Error Detection and Recovery
S-7	SLO-1	Gripper type	Homogeneous transformation	Forward kinematics of 3 DOF RRR spatial manipulator	Vision system for robot	Robot cycle time analysis
	SLO-2	Design of mechanical gripper and grasping	Numerical problem solving	Forward kinematics of 3 DOF RRR spatial manipulator	Architecture	Robot cycle time analysis
S-8	SLO-1	Various gripper in robot	Operators and mapping concept	Forward Kinematics of RPY wrist	Case study on vision system	Economic analysis of robot
	SLO-2	Selection criteria	Case study- numerical problem solving	Forward Kinematics of RPY wrist	Case study on vision system	Economic analysis of robot
S-9	SLO-1	Interpreting various data in the the robot data sheet	Compound Transformation	Forward kinematics of 4DOF SCARA robot		
	SLO-2	Interpreting various data in the the robot data sheet	Case Study	Forward kinematics of 4DOF SCARA robot		
S-10	SLO-1		Operators and mapping concept	Introduction to inverse kinematics		
	SLO-2		Case study- numerical	Inverse kinematics of RR planar manipulator- geometric approach		
S-11	SLO-1		Compound transformation	Issues in inverse kinematics		
	SLO-2		Case study	Issues in inverse kinematics		
S-12	SLO-1		Case study of transformations in robotics			
	SLO-2		Case study of transformations in robotics			

Learning Resources	1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012. 2. John J. Craig, "Introduction to Robotics", 3rd Edition, Addison Wesley, ISE 2008. 3. Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publishing Company Limited, 2012.	4. Arthor Critchlow, "Introduction to Robotics",1st edition, Macmillan, 2009. 5. Mohsen Shahinpoor, "A Robot Engineering Text Book", 1st edition, Harper and Row, 2004 6. Sterling Kinney J, "Indeterminate Structural Analysis", 1st edition, Narosa Publishing House, 1987.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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

Course Code	18MHE452T	Course Name	MECHANICS OF MANIPULATION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHE501T-Robotics*	Co-requisite Course	*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 complexity and method of solving inverse kinematics for an manipulator robot*
CLR-2 :	*Understand the concept of Jacobian and static forces applied to manipulator*
CLR-3 :	*Learn the importance of singularity and workspace in manipulator robot*
CLR-4 :	*Understand and solve dynamics problem for the manipulator*
CLR-5 :	*Understand the parallel configuration of robot*
CLR-6 :	*To get an overview of challenges involved in manipulator robotics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Solve the inverse kinematics problem for serial manipulators*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Compute the Jacobian matrix and static forces in manipulator*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Understand the important concept of singularity and its computation*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Compute the dynamic model of a serial manipulator*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Understand the parallel configuration of robot*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Get conversant with overall challenges involved in manipulators*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Manipulator Kinematics	Velocity Analysis	Singularity and Workspace analysis	Dynamic Modelling	Parallel Manipulator
Duration (hour)		9	11	10	8	7
S-1	SLO-1	*Forward kinematics of 6 DOF articulated arm*	*Description/Notation for time varying position and orientation*	*Concept of Singularity*	*Introduction to dynamics*	*Introduction to parallel manipulators*
	SLO-2	*Forward kinematics of 6 DOF articulated arm*	*Example*	*Types and consequences*	*Inertia, centrifugal force, coriolis force etc*	*Comparison with serial and parallel manipulator*
S-2	SLO-1	*Forward kinematics of a Stanford Manipulator*	*Linear velocity vector for rigid bodies*	*Singularity computation using Jacobian*	*Understanding dynamics of a simple system- mass spring damper system*	*Various configuration of parallel manipulator*
	SLO-2	*Forward kinematics of a Stanford Manipulator*	*Angular velocity vector for rigid bodies*	*Example using RR Manipulator*	*Inverse and forward dynamics*	*Degree of freedom computation of parallel manipulator*
S-3	SLO-1	*Inverse kinematics Introduction*	*Manipulator Jacobian*	*Singularity computation of RPY wrist*	*Lagrangian formulation*	*Forward and inverse kinematics of a parallel manipulator*
	SLO-2	*Issues in inverse kinematics*	*Importance of Jacobain matrix*	*Singularity computation of RPY wrist*	*Computing generalized torque/force through Lagrangian-Euler (LE) method*	*Challenges in forward kinematics*
S-4	SLO-1	*Algebraic and geometric method for RRR manipulator*	*Linear velocity Jacobian*	*Singularity computation of 6 DOF articulated arm*	*Dynamic model of a RR Planar manipulator using LE method*	*Inverse Kinematics of a planar parallel manipulator*
	SLO-2	*Algebraic and geometric method for RRR manipulator*	*Derivation for RR planar manipulator*	*Singularity computation of 6 DOF articulated arm*	*Dynamic model of a RR Planar manipulator using LE method*	*Inverse Kinematics of a planar parallel manipulator*
S-5	SLO-1	*Inverse kinematics Computation- Closed loop solution*	*Linear and angular velocity Jacobian computation*	*Work space analysis*	*Newton-Euler Formulation*	*Inverse Kinematics of a spatial parallel manipulator*
	SLO-2	*Case study- spherical wrist*	*Linear and angular velocity Jacobian*	*Work space analysis*	*Computing generalized torque/force*	*Inverse Kinematics of a spatial parallel*

			computation		through Newton Euler method	manipulator
S-6	SLO-1	Inverse kinematics of articulated arm (6 DOF)	Jacobian Computation for RPY wrist	Introduction to Trajectory Planning	Dynamic model of a RR Planar manipulator using LE method	Velocity analysis
	SLO-2	Inverse kinematics of articulated arm (6 DOF)	Jacobian computation for RPY wrist	Joint space and Cartesian space	Dynamic model of a RR Planar manipulator using LE method	Jacobian computation
S-7	SLO-1	Inverse kinematics of Stanford manipulator	Jacobian computation for articulated arm	Joint space trajectory planning	Dynamic model of a inverted pendulum	Workspace analysis
	SLO-2	Inverse kinematics of Stanford manipulator	Jacobian computation for articulated arm	Example of cubic polynomial	Dynamic model of a inverted pendulum	Example
S-8	SLO-1	Computation consideration for inverse kinematics	Static forces in manipulator	Joint space trajectory planning via points	Dynamic model of a SCARA robot	
	SLO-2	Example	Static forces in manipulator- Example	Cubic polynomial via points	Dynamic model of a SCARA robot	
S-9	SLO-1	Forward and Inverse Kinematics in robot control	Jacobian in force domain	Cartesian space trajectory planning		
	SLO-2	Example	Derivation	Case study		
S-10	SLO-1		Static force computation of a planar RR manipulator	Problem in Cartesian space planning		
	SLO-2		Static force computation of a planar RR manipulator	Example		
S-11	SLO-1		Cartesian transformation of velocities and forces			
	SLO-2		Example			

Learning Resources	1. John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008. 2. Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008. 3. J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006. 4. Saeed B.Niku, "Introduction to Robotics Analysis, Systems and Applications", 2nd edition, Prentice Hall of India, 2009.	5. Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India Learning, 2009. 6. Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007. 7. Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition 8. McGraw Hill, 2008.8. Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Ganesh Ram, Intel Labs ,Bangalore, ganeshram.nandakumar.@intel.com	1. Dr., R. Thiyagarajan, Visiting faculty, IIT Madras, thiyaguiitm@gmail.com	1. Dr. G. Murali, SRMIST
2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu	2. Ranjith Pillai R, SRMIST

Course Code	18MHE453T	Course Name	MOBILE ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	Formulate the challenges in developing autonomous mobile robots
CLR-2 :	Abstract kinematic control of wheeled mobile robots
CLR-3 :	Understand the challenges involved in sensory perception for mobile robots
CLR-4 :	Understand the mechanics of legged robots for locomotion
CLR-5 :	Comprehend the challenges and configurations of aerial and underwater mobile robots
CLR-6 :	Build the foundations of mobile robots in various modalities

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	Appreciate the various problems to be addressed in autonomous mobile robots	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	Understand the various types and configurations of wheeled and legged mobile robots	3	80	75	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	Formulate the kinematics of wheeled and legged mobile robots of popular configurations	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	Build the dynamic model of multi-rotor aerial and underwater robots	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	Understand the issues in interpreting proprioceptive and exteroceptive sensory data on-board mobile robots	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	Build the required foundation for developing autonomous mobile robots.	2	80	75	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Kinematics and Control of Mobile Robots	Sensors for Mobile Robots	Legged Robots	Aerial and Underwater Robots
Duration (hour)		6	10	10	9	10
S-1	SLO-1	Mobile robots vs. manipulators	Kinematic constraints of a fixed standard wheel	Sensors for mobile robots	Introduction to limbed systems	Non-ground modality
	SLO-2	Introduction to autonomous mobile robots	Derivation	Definitions, classification	Comparison with wheeled systems	Case studies
S-2	SLO-1	Locomotion aspects of mobile robots	Kinematic constraints of a omni-directional wheel	Characteristics applicable to mobile robots	Configurations of limbed systems	Aerial robots
	SLO-2	Locomotion aspects of mobile robots	Derivation	Characteristics applicable to mobile robots	Case studies	Types and comparison
S-3	SLO-1	Introduction to wheeled mobile robots	Forward kinematic of three wheeled differential drive robot	Physical and computational attributes of sensors applicable to mobile robots	Conceptual design of limbed systems	Multi-rotor aerial robot
	SLO-2	Wheel types	Derivation	Sensor noise and sensor aliasing	Design issues	Types and applications
S-4	SLO-1	Wheeled configurations	Forward kinematics of a three wheeled omni-directional robot	GPS and heading sensors	Kinematics of quad-limbed configuration	Quadrotor aerial robot
	SLO-2	Two, three, four, five and six wheeled	Derivation	Principles, challenges and interpretation	Derivation	Modelling of dynamics
S-5	SLO-1	Maneuverability, controllability	Degree of freedom, differential degrees of freedom,	Light and sound based ranging	Control strategy	Modelling of flight controller
	SLO-2	Stability of mobile robots	Holonomic and non-holonomic constraints, degree of maneuverability	Principles, challenges and interpretation	Model of control algorithm for legged robot	Derivation

S-6	SLO-1	*Wheeled locomotion*	*Mobility analysis of various wheeled configurations*	*Wheel odometry*	*Design of biped configuration*	*Commercial flight controllers*
	SLO-2	*Case studies*	*Mobility analysis of various wheeled configurations*	*Algorithm*	*Kinematics of a biped configuration*	*Specifications and selection criteria*
S-7	SLO-1		*Workspace and trajectory considerations*	*Wheel odometry critical analysis*	*Design case study of a complete humanoid*	*Underwater vehicles*
	SLO-2		*Comparison*	*Wheel odometry error reduction*	*Considerations and challenges*	*Foundations topics and challenges*
S-8	SLO-1		*State space modelling of three wheeled differential drive robot*	*Vision for mobile robots*	*Mechanical system design*	*Types of underwater vehicles*
	SLO-2		*Derivation*	*Techniques and purpose*	*Case study*	*Comparison*
S-9	SLO-1		*Go-goal controller*	*Multi-sensor combinations*	*Electrical system design*	*Modelling of underwater dynamics*
	SLO-2		*Block diagram level model*	*Need and types*	*Case study*	*Derivation*
S- 10	SLO-1		*Cruise controllers*	*Sensor fusion algorithms*		*Modelling of underwater vehicle*
	SLO-2		*Block diagram level model*	*Types and selection*		*Derivation*

Learning Resources	1. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.* 2. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016.*	3. *Perter Corke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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

Course Code	18MHE454T	Course Name	ROBOT CONTROL	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHE501T - Robotics*	Co-requisite Course	*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 position control schemes in robot*
CLR-2 :	*Define the importance of force control in robot application*
CLR-3 :	*Learn the force/position control and trajectory control schemes in robotics*
CLR-4 :	*Get familiar with the nonlinear systems and its control strategy*
CLR-5 :	*Learn the various programming methods in robot*
CLR-6 :	*To get an insight of the role of kinematics and dynamics in control*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*Understand various position control schemes and its implementation*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Apply various force control schemes*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Derive the force/position and trajectory control schemes for manipulators*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Learn the complexities of nonlinear systems and various control schemes*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Understand the various programming methods in robotics*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Learn various position control schemes and its implementation*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Introduction to Position control	Introduction to Force control	Force/Position Control	Introduction to non linear control	Introduction to ROS
Duration (hour)		10	11	12	6	6
S-1	SLO-1	*Review of position control*	*Introduction to force control*	*Introduction to hybrid force position control problem*	*Introduction to nonlinear and time varying systems*	*Robot language classification*
	SLO-2	*Mass- spring damper system*	*Application of force control*	*Example*	*General representation*	*Programming methods: Lead through method, teach pendent method*
S-2	SLO-1	*Various linear control schemes*	*Frame work for force control scheme*	*Hybrid force/position control architecture*	*Control problem for manipulator*	*Syntax features and applications of various programming languages*
	SLO-2	*Characteristics of linear control*	*Define- Artificial and natural constraints*	*Example*	*Practical considerations*	*Examples*
S-3	SLO-1	*Position control of second order system*	*Case study to define artificial and natural constraint*	*Selection matrices*	*Ulyanovsk stability analysis*	*Inter locking commands*
	SLO-2	*PI implementation*	*Case study to define artificial and natural constraint*	*Case study to describe selection matrices*	*Example*	*Safety features*
S-4	SLO-1	*Position control of second order system*	*Description of force control task*	*Case study for hybrid force position control scheme*	*Introduction to nonlinear controllers*	*Introduction to Robot Operating System (ROS)*
	SLO-2	*PD implementation*	*Example- Peg in hole assembly*	*Case study for hybrid force position control scheme*	*Description of fuzzy based control*	*ROS examples*
S-5	SLO-1	*Position control of second order system*	*Force control of mass spring system*	*Trajectory control*	*Case study for fuzzy based control*	*Introduction to programming using ROS Industrial ROS*

	SLO-2	*PID implementation*	*Force control of mass spring system*	*Cartesian and joint space control*	*Use of Lyapunov criteria to understand stability*	*ROS examples*
S-6	SLO-1	*Modelling of 1 DOF manipulator Joint*	*Dynamics based control*	*Cubic polynomial trajectories*	*Introduction to sliding mode control*	*Programming for point to point /continuous Operations*
	SLO-2	*Deriving the mathematical model*	*General dynamics representation*	*Derivation*	*Example*	*Case Study*
S-7	SLO-1	*Partitioned PD (PPD)control scheme*	*Computed torque control*	*Point o point motion without via points*		
	SLO-2	*Architecture and difference from PD control*	*Architecture*	*Derivation*		
S-8	SLO-1	*Application of partitioned PD control scheme to 1 DOF manipulator joint*	*Impedance force/toque control*	*Point to point motion with via points*		
	SLO-2	*Analysis*	*Example*	*Derivation*		
S-9	SLO-1	*Modeling the PPD with external disturbance*	*Force tracking characteristics of impedance control*	*Linear function with parabolic blend*		
	SLO-2	*Architecture with external disturbance*	*Example of manipulator interaction with environment*	*Linear function with parabolic blend - example*		
S-10	SLO-1	*Partitioned PID control scheme*	*Passive compliance*	*Cartesian space techniques*		
	SLO-2	*Architecture*	*Example*	*Description of path - example*		
S-11	SLO-1		*Active compliance*	*Defining straight line path*		
	SLO-2		*Compliance through softening position gain*	*Derivation*		
S-12	SLO-1			*Implementation method*		
	SLO-2			*Implementation example*		

Learning Resources	*1. John J. Craig, "Introduction to Robotics", 3rd edition, Addison Wesley, ISE 2008.* *2. R.K Mittal and I J Nagrath , "Robotics and control Tata McGraw", 5th edition, Hill, 2003.*	*3. S.K Saha,"Introduction to Robotics" , 2nd edition, Tata McGraw Hill, 2008.* *4. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.* *5. Aaron Martinez,"Learning ROS for robotics programming", 1st edition, PACKT Publishing, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Mr. Mohammed Sagheer ,Wabco Technology Center ,India, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT,Anna University, pkarthikeyan@annauniv.edu*	*2. Ranjith Pillai R, SRMIST*

Course Code	18MHE455T	Course Name	COMPUTER VISION AND ITS APPLICATIONS	Course Category	*E*	*Professional Elective*	L	T	P	C
							3	0	0	3

Pre-requisite Course	*Nil*	Co-requisite Course	*Nil*	Progressive Courses	*18MHE506T - Advanced Computer Vision*
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 approaching vision technology from a biological inspiration*
CLR-2 :	*Appreciate the mathematics of projection based system*
CLR-3 :	*Understand the various specifications of vision hardware*
CLR-4 :	*Understand basics of image data and develop some basic image processing algorithms for enhancement and analysis*
CLR-5 :	*Get introduced about computer vision applied for 3-D scene reconstruction.*
CLR-6 :	*Understand the foundations of the vision as a potential technology for automata*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	2 Expected Proficiency (%)	3 Expected Attainment (%)	Program Learning Outcomes (PLO) 1 Engineering Knowledge	2 Problem Analysis	3 Design & Development	4 Analysis, Design, Research	5 Modern Tool Usage	6 Society & Culture	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	13 PSO - 1	14 PSO - 2	15 PSO - 3
CLO-1 :	*Formulate the mathematical expressions of geometric camera modelling and calibration*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-2 :	*Interpret the specifications of vision hardware*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-3 :	*Develop of basic image processing algorithms*	*2*	*70*	*65*	*H*	*M*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-4 :	*Apply some algorithms for feature extraction*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-5 :	*Understand the foundations of stereo vision technique*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-6 :	*Handle applications involving image data for automata*	*2*	*80*	*75*	*H*	*M-*	*M*	*M*	*M*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*

		Introduction	Vision Hardware	Image Processing	Image Analysis	3-D Vision
Duration (hour)		8	9	10	9	9
S-1	SLO-1	*Introduction to Vision*	*Scene constraints*	*Vision software basics*	*Feature extraction*	*Introduction to the multi-view geometry*
	SLO-2	*Terminologies of fields*	*Fundamentals of lighting*	*Types and selection*	*Region features and classification - types*	*Scene reconstruction and motion estimation problem*
S-2	SLO-1	*Comparison of biological and computer vision*	*Light sources*	*Basics of digital image*	*Key point features*	*Geometry of a stereo vision system*
	SLO-2	*Specifications and limitations*	*Types, selection criteria*	*Sampling, quantization effects*	*Applications*	*Correspondence problem*
S-3	SLO-1	*Projective geometry*	*Lighting techniques*	*Point operations*	*Corner detection*	*Epipolar geometry*
	SLO-2	*Basics*	*Types and selection criteria*	*2-D convolution*	*Harris corner detection*	*Estimation of fundamental and essential matrix*
S-4	SLO-1	*Modelling of geometric image formation*	*Lenses, specifications*	*Image smoothing in spatial domain*	*Critical analysis of Harris corner detection*	*Epipolar constraint*
	SLO-2	*Derivation*	*Optical filters, specifications*	*Image sharpening and edge detection in spatial domain*	*Limitations and motivation for going beyond corner detection*	*Applications of epipolar constraint*
S-5	SLO-1	*Modelling of camera distortion and artifacts*	*Image sensors*	*Discrete Fourier Transform (DFT)*	*Key point descriptors*	*Application of epipolar constraint in image stitching*
	SLO-2	*Derivation*	*Specifications*	*Frequency domain filtering basics*	*Motivation and applications*	*Implementation details*
S-6	SLO-1	*Camera calibration*	*CCD sensor specifications*	*Smoothing sharpening in frequency domain*	*Scale Invariant Feature Transform (SIFT) key point descriptor*	*Epipolar rectification*
	SLO-2	*Methods of camera calibration*	*CMOS sensor specifications*	*Smoothing sharpening in frequency domain*	*Scale space construction and difference of Gaussian*	*Metric reconstruction*

S-7	SLO-1	*Estimation of projection matrix*	*Comparison of CCD and CMOS*	*Morphological image processing*	*Filtering of low contrast features*	*Non-metrical reconstruction types*
	SLO-2	*Derivation*	*Advanced sensor technologies*	*Erosion, dilation, opening and closing*	*SIFT descriptor*	*Multi-view stereo vision*
S-8	SLO-1	*Experimental performance assessment in computer vision*	*Camera computer interfaces*	*Color image processing motivation*	*Matching algorithms*	*Issues and challenges*
	SLO-2	*Metrics and example usage*	*Types and selection*	*HSI space color image processing*	*Gray-level and correlation based matching*	*Applications of stereo vision*
S-9	SLO-1		*Application case studies*	*Application case studies*	*Descriptor based matching*	*Visual odometry case study*
	SLO-2		*Hardware selection exercise*	*Image smoothing and sharpening*	*Implementation details*	*Application in driverless cars*
S-10	SLO-1			*Application case studies*		
	SLO-2			*Morphology and colour processing*		

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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2. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. K. Sivanathan, SRMIST*

Course Code	18MHE456T	Course Name	ADVANCED COMPUTER VISION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHE505T - Computer Vision and Its Applications*	Co-requisite Course	*Nil*	Progressive Courses	*18MHE507T - Vision Guided Robotics*
Course Offering Department	*Mechatronics Engineering*	Data Book/Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*To understand the various active methods of reconstruction techniques*
CLR-2 :	*To comprehend various segmentation techniques used in computer vision tasks*
CLR-3 :	*The understand various recognition*
CLR-4 :	*To get introduced to classical neural networks and machine learning basics*
CLR-5 :	*To understand deep learning techniques for computer vision tasks*
CLR-6 :	*Application specific deep learning networks*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*To be able to appreciate the mathematics of basic computer vision principles*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*To be able to understand the active computer vision techniques and shape from focus*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*To be able to comprehend clustering and segmentation methods*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*To be able to understand recognition principles and basic mathematics of the same*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*To appreciate neural networks and deep neural networks based learning for computer vision tasks*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*To implement deep learning for common computer vision tasks*	2	80	75	H	M	M	M	M	-	-	-	L	L	-	L	H	M	-

		Shape From Focus and Active Methods	Segmentation	Recognition	Deep Learning	Augmented Reality and Mixed Reality
Duration (hour)		8	10	7	10	10
S-1	SLO-1	*Modelling image focus*	*Introduction to segmentation*	*Introduction to recognition*	*Convolutional neural networks*	*The Reality–Virtuality continuum*
	SLO-2	*Modelling image focus*	*Types*	*Challenges and approaches*	*Convolution, pooling*	*The Reality–Virtuality continuum*
S-2	SLO-1	*Shape from focus*	*Introduction to clustering*	*K-nearest neighbor algorithm*	*Activation functions, initialization*	*Virtual, augmented and mixed reality, an historical perspective*
	SLO-2	*Principle and hardware required*	*Methods relevant to computer vision*	*Principle and underlying mathematics*	*Dropout, batch normalization*	*Industrial applicability of virtual, augmented and mixed reality*
S-3	SLO-1	*Focus measures*	*Agglomerative clustering*	*Numerical problem solving for a sample recognition using K-nearest*	*Deep learning hardware*	*Design and implementation of an immersive user experience*
	SLO-2	*Scene reconstruction*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using K-nearest*	*CPU, GPU, TPU*	*Design and implementation of an immersive user experience*
S-4	SLO-1	*Active methods*	*Numerical problem on agglomerative clustering*	*Principal Component Analysis (PCA)*	*Tuning neural networks*	*The VR-AR-MR system architecture*
	SLO-2	*Comparison with passive techniques*	*Numerical problem on agglomerative clustering*	*Principle and underlying mathematics*	*Best practices*	*The VR-AR-MR system architecture*
S-5	SLO-1	*Laser triangulation*	*K-means clustering*	*Numerical problem solving for a sample recognition using PCA*	*Training neural networks*	*Tracking system*

	SLO-2	*Principle, working and specifications*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using PCA*	*Update rules, ensembles*	*Tracking system*
S-6	SLO-1	*Structured light reconstruction*	*Numerical problem on agglomerative clustering*	*Linear Discriminant Analysis (LDA)*	*Data augmentation*	*Visual, aural, and haptic display*
	SLO-2	*Principle, working and specifications*	*Numerical problem on agglomerative clustering*	*Principle and underlying mathematics*	*Transfer learning*	*Design principles*
S-7	SLO-1	*LIDAR*	*Mean-shift clustering*	*Numerical problem solving for a sample recognition using LDA*	*Popular CNN architectures For image classification*	*Usability guidelines*
	SLO-2	*Principle, working and specifications*	*Principle and underlying mathematics*	*Numerical problem solving for a sample recognition using LDA*	*Challenges addressed and novelty*	*Usability guidelines*
S-8	SLO-1	*Application case studies of active methods*	*Numerical problem on agglomerative clustering*		*Popular CNN architectures for object detection*	*Common Interaction Techniques for Mixed Reality*
	SLO-2	*Application case studies of active methods*	*Numerical problem on agglomerative clustering*		*Challenges addressed and novelty*	*Common Navigation Techniques*
S-9	SLO-1		*Introduction to classification*		*Applications of deep learning - semantic segmentation*	*Interaction design process*
	SLO-2		*Types, applications*		*Applications of deep learning or instance segmentation*	*Interaction design process*
S-10	SLO-1		*Linear classifiers*		*Applications of deep learning - activity understanding*	*Future of computer computer vision*
	SLO-2		*Implementation details*		*Types*	*Open problems*

Learning Resources	1. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* 2. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, 1st Edition, MIT Press, 2016.* 3. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018.*	4. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1st Edition, Prentice Hall, 1998.* 5. *Kharis O'Connell, "Designing Mixed Reality", 1st Edition, O' Reilly, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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Course Code	18MHE457T	Course Name	VISION GUIDED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Course	*18MHE505T - Computer Vision and Its Applications*	Co-requisite Course	*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 :	*To understand how computer vision aids in manipulator's guidance*
CLR-2 :	*To understand how computer vision aids in mobile robot's guidance*
CLR-3 :	*To get awareness about visual servoing techniques*
CLR-4 :	*To get awareness about visual slam and visual odometry*
CLR-5 :	*To gain knowledge about optical flow methods and their applications*
CLR-6 :	*To get to knwo about the advanced approaches in visual servoing*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	2: Expected Proficiency (%)	3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. & Finance	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO - 3
CLO-1 :	*To be able to appreciate the various roles of computer vision in manipulator and mobile robotics*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*To be able to comprehend the basics mathematics of visual servoing architectures*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*To be able to appreciate the applications of computer vision for mobile robotics*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*To be able to implement optical flow methods to understand motion related features from images*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*To have the competency in developing tracking algorithms based on vision data*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-6 :	*To be conversant in the futuristic approaches in visual servoing*	2	80	75	H	M-	M	M	M	-	-	-	L	L	-	L	H	M	-

		Introduction	Visual Servoing	Vision for Mobile Robots	Optical Flow and Tracking	Advanced Topics
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Introduction to vision for Robotics*	*Mathematical formulation of visual servo problem*	*Introduction to simultaneous localization and mapping*	*Formulation of the motion analysis*	*Hybrid visual servoing, partitioned visual servoing*
	SLO-2	*Significance of vision as a external state sensing technology*	*Derivation*	*Visual SLAM (VSLAM)*	*Formulation of the motion analysis*	*Switching schemes in visual servoing*
S-2	SLO-1	*Vision for manipulators*	*Classification of visual servoing architectures*	*VSLAM Basics*	*Motion field of rigid objects*	*Joint space control of eye-in-hand*
	SLO-2	*Vision for mobile robots*	*Classification of visual servoing architectures*	*VSLAM Basics*	*Aperture problem*	*Joint space control of eye-in-hand*
S-3	SLO-1	*Modelling velocity of a rigid object*	*Image based visual servoing (IBVS)*	*VSLAM approaches*	*Optical flow*	*Joint space control of eye-to-hand systems*
	SLO-2	*Derivation*	*Interaction matrix derivation*	*VSLAM approaches*	*Motion field*	*Joint space control of eye-to-hand systems*
S-4	SLO-1	*Camera configurations in vision guided robots*	*Geometrical interpretation of IBVS*	*Introduction to visual odometry (VO)*	*Brightness constancy equation*	*Motion based segmentation*
	SLO-2	*Camera configurations in vision guided robots*	*Derivation*	*Introduction to visual odometry (VO)*	*Validity*	*Motion based segmentation*
S-5	SLO-1	*Triangulation*	*Stability analysis*	*VO - motion from image feature correspondences*	*Estimating motion field - differential techniques*	*Structure from motion (SFM)*

	SLO-2	*Derivation*	*Stability analysis*	*VO - motion from image feature correspondences*	*Estimating motion field - differential techniques*	*Multi-view SFM*
S-6	SLO-1	*Basic equation of triangulation*	*IBVS with stereo vision system – a case study*	*VO – motion from 3-D structure*	*Estimating motion field - feature based techniques*	*Retrieving 3-D structure*
	SLO-2	*Derivation*	*IBVS with stereo vision system – a case study*	*VO – motion from 3-D structure*	*Estimating motion field - feature based techniques*	*Retrieving 3-D structure*
S-7	SLO-1	*Vision based pose estimation*	*IBVS with other geometrical features*	*Comparison between VSLAM techniques*	*Target tracking*	*Motion from motion field*
	SLO-2	*Detailed description of any one approach*	*Direct estimation*	*VO calibration techniques*	*Challenges and solutions*	*Motion from motion field*
S-8	SLO-1		*Position based visual servoing*	*Application case study on VSLAM*	*Kalman filtering basics*	
	SLO-2		*Point feature based motion*	*Application case study on VSLAM*	*Kalman filtering basics*	
S-9	SLO-1		*Pose based motion*	*Application case study on VSLAM*	*Kalman tracking*	
	SLO-2		*Pose based motion*	*Application case study on VSLAM*	*Kalman tracking*	
S-10	SLO-1		*Calibration for visual servoing systems*	*Application case study on VO*	*Application case study on visual tracking*	
	SLO-2		*Calibration for visual servoing systems*	*Application case study on VO*	*Application case study on visual tracking*	

Learning Resources	1. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* 2. *Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 2nd Edition, Springer, 2016.*	3. *D. Scaramuzza and F. Fraundorfer, "Visual Odometry [Tutorial]," in IEEE Robotics & Automation Magazine, vol. 18, no. 4, pp. 80-92, Dec. 2011.* 4. *F. Fraundorfer and D. Scaramuzza, "Visual Odometry : Part II: Matching, Robustness, Optimization, and Applications," in IEEE Robotics & Automation Magazine, vol. 19, no. 2, pp. 78-90, June 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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

Course Code	18MHE458T	Course Name	ADVANCED ROBOTICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*15MHE501T - Robotics*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Learn the concepts of singularity, statics and to compute dynamics of complex configuration*
CLR-2 :	*Understand the concepts and challenges involved in multirobot systems*
CLR-3 :	*Understand modeling of flexible robots*
CLR-4 :	*Learn the complexities of wheeled mobile robot in uneven terrain*
CLR-5 :	*Introduce the advanced concepts of robotics like coorperative robot, haptics and telerobotic systems*
CLR-6 :	*get an understanding about the current state of the art research topics in robotics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Understand the approaches to solve for singularity and dynamics of manipulator*	2	80	70	H	M	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-2 :	*Learn the concept of multirobot systems and its research challenges*	2	80	70	H	H	M	H	M	-	-	-	-	-	-	H	H	-	-
CLO-3 :	*Understand the modeling and control of flexible robots*	2	80	70	H	H	M	H	M	-	-	-	H	-	-	H	H	-	-
CLO-4 :	*Understand mathematical concepts of defining the wheeled mobile robot in uneven terrain*	2	80	70	H	H	H	H	M	-	-	-	M	-	-	H	H	-	-
CLO-5 :	*Learn the importance and complexities of coorperative robot, haptics and telerobotic systems*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-
CLO-6 :	*Ability to address current advanced topics of research in the field of robotics*	2	80	70	H	H	M	H	M	-	-	-	M	-	-	H	H	-	-

		Manipulator Robots	Multi Robot Systems	Modelling and control of flexible robots	Wheeled Mobile Robot	Advanced Topics
Duration (hour)		8	7	10	8	12
S-1	SLO-1	*Jacobian for serial manipulator*	*Architecture of multirobot systems*	*Introduction to flexible robots*	*Introduction to wheeled mobile robot (WMR)*	*Introduction to cooperative manipulators*
	SLO-2	*Numerical*	*History and application*	*Application*	*Two and three wheeled WMR on flat surfaces*	*Historical overview*
S-2	SLO-1	*Jacobian for parallel Manipulators*	*Communication*	*Models of flexible Links*	*Concepts of slip*	*Introduction to kinematics and statics*
	SLO-2	*Numerical*	*Example*	*Numerical*	*Slip Modelling*	*Example*
S-3	SLO-1	*Singularity analysis*	*Introduction to swarm robots*	*Models of flexible Joints*	*World and terrain models for natural environment*	*Dynamics and load distribution*
	SLO-2	*Loss and gain of degree of freedom*	*Example*	*Numerical*	*Model*	*Example*
S-4	SLO-1	*Statics and force transformation matrix for Stewart Gough platform*	*Heterogeneity*	*Kinematic Modelling of multilink flexible robots*	*Dynamic environments*	*Control of cooperative manipulator*
	SLO-2	*Derivation*	*Heterogeneity*	*Numerical*	*Example*	*Example*
S-5	SLO-1	*Singularity analysis of Stewart Gough platform*	*Task allocation and learning*	*Kinematic modelling of multilink flexible robots*	*WMR on uneven terrain*	*Overview of haptics*
	SLO-2	*Numerical Analysis*	*Case study*	*Numerical*	*Example*	*Importance*
S-6	SLO-1	*Introduction to recursive dynamics*	*Control challenges*	*Introduction to dynamics of flexible link manipulator*	*Design of slip free motion on uneven terrain*	*Haptic device design*

	SLO-2	*Numerical procedure*	*Communication for control of networked robots*	*Notations and terms*	*Design*	*Example*
S-7	SLO-1	*Dynamics of Stewart Gough platform*	*Communication for perception*	*Dynamic computation*	*Dynamics and static stability of three wheeled WMR on uneven terrain*	*Haptic rendering*
	SLO-2	*Numerical*	*Control for perception*	*Numerical*	*Numerical analysis*	
S-8	SLO-1	*Simulation and experimental case study on control of parallel manipulator*		*Control of flexible link manipulator*	*Case study of wheeled mobile robot on uneven terrain*	*Control and stability of haptic interfaces*
	SLO-2	*Case Study*		*Control equation*	*Case Study*	*Example*
S-9	SLO-1			*Numerical simulation for planar 2 link flexible manipulator*		*Introduction to tele robotic systems*
	SLO-2			*Simulation*		*Application*
S-10	SLO-1			*Simulation for planar 2 link flexible manipulator*		*Control architecture*
	SLO-2			*Simulation*		*Example*
S-11	SLO-1					*Bilateral control and force feedback*
	SLO-2					*Example*
S-12	SLO-1					*Communication and networking*
	SLO-2					*Example*

Learning Resources	1. *John J. Craig, "Introduction to Robotics Mechanics and Control", 3rd edition, Pearson, 2008.* 2. *Mark W. Spong and M. Vidyasagar, "Robot Dynamics and Control", 2nd edition, Wiley India, 2008.* 3. *J.P. Merlet, "Parallel Robots", 2nd edition, Springer, 2006.* 4. *Siciliano, B., and Khatib, O. (Editors), Handbook ofRobotics, 2nd edition, Springer, 2016.*	5. *Robert J. Schilling, "Fundamentals of Robotics Analysis and Control", 5th edition, Prentice Hall of India, 2009.* 6. *Mittal R.K., and Nagrath I.J., "Robotics and Control", 1st edition, Tata McGraw Hill, 2007.* 7. *Fu K., Gonzalez R., and Lee C. S. G., "Robotics: Control, Sensing, Vision and Intelligence", 1st edition, McGraw Hill, 2008.* 8. *Tsuneo Yohikwa, "Foundations of Robotics Analysis and Control", 2nd edition, MIT Press, 2003.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember / Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply / Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate / Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

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

Course Code	18MHE459T	Course Name	APPLIED 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 :	*Understand the various types of industrial, field and service robots and their characteristics and capabilities*
CLR-2 :	*Equip with the knowledge of mathematical modeling of specialized robots*
CLR-3 :	*Familiarize with the operation of robots and processes involved*
CLR-4 :	*Select the right robot with required configurations and specifications for given applications*
CLR-5 :	*Familiarize with the applications of various field and service robots*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Recognize the various types of industrial, field and service robots and their characteristics and capabilities*	*2*	*75*	*70*	*H*	*H*	*L*	*H*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*H*	*H*	*H*
CLO-2 :	*Develop mathematical modeling of specialized robots*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*M*	*M*
CLO-3 :	*Familiarize with the operation of robots and processes involved*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*M*	*M*
CLO-4 :	*Decide the right robot with required configurations and specifications for given applications*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*M*	*M*
CLO-5 :	*Utilize the field and service robots for various applications*	*3*	*75*	*70*	*H*	*H*	*M*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*M*	*M*	*M*

		Applications of Robots in Industries	Underwater and Aerial Robots	Field robots	Robots in Surgery and Rehabilitation	Entertainment and Personal Robots
Duration (hour)		9	10	9	9	8
S-1	SLO-1	*Introduction to Robotics- Overview of syllabus*	*Autonomous Underwater vehicles (AUV)*	*Forestry- Robot locomotion*	*Medical robotics- Introduction*	*Cleaning robots*
	SLO-2	*A short history of Industrial robots*	*Autonomous Surface Vehicles (ASV)*	*Forestry automation*	*core concepts- technology*	*Cleaning robots*
S-2	SLO-1	*Typical applications & robot configurations*	*Modeling of AUV*	*SLAM in forestry*	*Medical robotic systems*	*Lawn moving robots*
	SLO-2	*Typical applications & robot configurations*	*Modeling of AUV*	*Autonomous robots for silviculture and treatment*	*Medical robotic systems*	*Lawn moving robots*
S-3	SLO-1	*Robots in welding*	*Modeling of ASV*	*Broad acre Applications*	*Medical robotic systems-research areas and applications*	*Smart appliances and smart homes*
	SLO-2	*Robots in welding*	*Modeling of ASV*	*Automatic guidance- sowing weeding-spraying*	*Medical robotic systems-research areas and applications*	*Smart appliances and smart homes*
S-4	SLO-1	*Car body assembly & Painting*	*Sensor systems and actuation systems*	*Automatic guidance- sowing weeding-spraying*	*Rehabilitation and health care robotics-overview-*	*The role of robots in education*
	SLO-2	*Car body assembly & Painting*	*Motion control system -guidance and control*	*Broad-acre harvesting*	*Rehabilitation and health care robotics-overview-*	*Educational robotic platforms*
S-5	SLO-1	*Material transfer and automation*	*Challenges in Localization of AUV & ASV*	*Horticulture: picking of fruits*	*Physical therapy and training robots*	*Robots and informal learning venues*
	SLO-2	*Machining*	*Remotely operated vehicles (ROVs)*	*Horticulture: picking of fruits*	*Physical therapy and training robots*	*Robots and informal learning venues*
S-6	SLO-1	*Kinematics and mechanisms review*	*Remotely operated vehicles, types and applications*	*Robot milking-sheep shearing*	*Aids for people with disabilities*	*Social robots that interact with people*

	SLO-2	*Kinematics and mechanisms review*	*Gliders*	*slaughtering-livestock inspection*	*Aids for people with disabilities*	*Social robot embodiment*
S-7	SLO-1	*Tasks descriptions- teaching and programming*	*History of Unmanned aerial vehicles (UAV)*	*Robots in construction*	*Smart prostheses and orthoses*	*Multimodal Communication*
	SLO-2	*Tasks descriptions- teaching and programming*	*Different configurations of fixed and rotary wing aerial vehicles*	*Unsolved problems in construction- future directions*	*Smart prostheses and orthoses*	*Expressive emotion-based interaction*
S-8	SLO-1	*End-effectors*	*Kinematics and dynamics of quadcopter*	*Robots for hazardous applications- enabling technologies*	*Diagnosis and monitoring*	*Socio-cognitive skills*
	SLO-2	*End-effectors and System integration*	*Modeling of Quad rotor aerial vehicle*	*Search and rescue robots*	*Diagnosis and monitoring*	*Promising robots- open issues*
S-9	SLO-1	*Challenges in system integration*	*Overall Control system for UAVs*	*Disaster characteristics and impact on robots*	*Open challenges in using robots in medical applications*	
	SLO-2	*Approaches to system integration*	*Guidance and Navigation of UAV*	*Robots actually used at disaster*	*Future directions*	
S-10	SLO-1		*Applications of UAVs*			
	SLO-2		*Applications of UAVs*			

Learning Resources	1. *Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016.* 2. *Yangsheng Xu Huihuan Qian Xinyu Wu, "Household and service robots", 1st edition, Elsevier Ltd, 2015* 3. *Aleksandar Lazinica, "Mobile Robots Towards new applications", 1st edition, Advanced Robotic Systems International, 2006*	4. *Gregory Dudek, Michael Jenkin, "Computational Principles of Mobile Robotics", 2nd Edition, Oxford University Press, 2010* 5. *L Marques,A de Almeida,M o Tokhi,G SVirk,"Advances in Mobile Robotics", 1st edition, World Scientific Publishing Co. Pte. Ltd. 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Guna Surendra, Gossamsetti, Hitachi, Japan. surendra.gossamsetti.bu@hitachi.com	*1. Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	*1. Mr. K. Sivanathan, SRMIST*
2. Mr. Visweswaran Jagadeesan , National Instruments. visweswaran.jagadeesan@ni.com	*2. Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*2. Mr. Ranjit Pillai, SRMIST*

Course Code	18MHE460T	Course Name	PLANNING AND DECISION MAKING IN 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 :	*To understand the mathematical foundations of planning algorithms*
CLR-2 :	*To get awareness of various algorithms used in localization of mobile robots*
CLR-3 :	*To get exposed to common algorithmic strategies for path planning of mobile robots*
CLR-4 :	*To get an understanding of motion control algorithms required for autonomous vehicles*
CLR-5 :	*To get awareness of strategies to simultaneously localize and map the environment*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO - 3
CLO-1 :	*Comprehend the mathematical foundations of localization and path planning algorithms*	3	80	75	H	H	M	L	L	-	-	-	L	L	-	L	H	M	-
CLO-2 :	*Implement localization algorithms based on probabilistic and optimal state estimation*	3	85	80	H	H	M	M	L	-	-	-	M	L	-	L	H	M	-
CLO-3 :	*Appreciate practical aspects of implementation of motion control algorithms for autonomous vehicles*	2	70	65	H	M	L	M	L	-	-	-	M	L	-	L	H	M	-
CLO-4 :	*Develop path planning algorithms for local and global path planning*	2	75	70	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-
CLO-5 :	*Implement algorithms for simultaneous localization and mapping*	2	85	80	H	M	M	M	M	-	-	-	M	L	-	L	H	M	-

		Introduction	Localization	Control	Optical Flow and Tracking	Advanced Topics
Duration (hour)		8	10	10	10	7
S-1	SLO-1	*Review of probability theory*	*Markov localization*	*Robot Motion*	*Motion planning*	*Introduction to SLAM*
	SLO-2	*Uniform distribution*	*Formulation, advantages and limitation*	*Smoothing Algorithm*	*Global and local path planning*	*Problem definition and Mathematical basis*
S-2	SLO-1	*Probability after sense*	*Numerical problem for Markov localization*	*Path Smoothing*	*Motivation and challenges*	*Taxonomy of SLAM problem*
	SLO-2	*Normalize distribution*	*Numerical problem for Markov localization*	*Zero Data Weight*	*Approaches*	*SLAM Paradigms*
S-3	SLO-1	*Phit and Pmiss*	*Introduction to optimal state estimation problem*	*PID control*	*A* star search*	*Extended Kalman Filter (EKF) SLAM*
	SLO-2	*Sum of probabilities*	*State estimator for localization*	*Implementation aspects of proportional control*	*Numerical example*	*Mathematical basics*
S-4	SLO-1	*Sense function*	*Gaussian introduction*	*Implementation aspects of integral control*	*D* lite search*	*Numerical example for EKF*
	SLO-2	*Exact motion*	*Variance comparison*	*Implementation aspects of derivative control*	*Numerical example*	*Numerical example for EKF*
S-5	SLO-1	*Move function*	*Maximize Gaussian*	*Systematic Bias*	*Expansion grid*	*Introduction to particle filters*
	SLO-2	*Bayes rule*	*Measurement and motion*	*Systematic Bias*	*Numerical example*	*Introduction to particle filters*
S-6	SLO-1	*Theorem of total probability*	*Parameter update*	*PID Tuning for autonomous mobile systems*	*Dynamic programming*	*Mathematical formulation of particle filter in the context of SLAM*
	SLO-2	*Numerical problems*	*New mean variance*	*PID Tuning for autonomous mobile systems*	*Numerical example*	*Mathematical formulation of particle filter in*

						the context of SLAM
S-7	SLO-1	*Introduction to localization*	*Gaussian motion*	*Parameter optimization*	*Vector field histogram*	*Fast SLAM*
	SLO-2	*Types and Challenges*	*Kalman filter pseudocode*	*Parameter optimization*	*Numerical example*	*Fast SLAM for point landmark example*
S-8	SLO-1	*Belief Representation*	*Kalman prediction*		*Selection of global and local path planning algorithms*	*Derivation*
	SLO-2	*Types and comparison*	*Kalman prediction*		*Application case study*	*Real world challenges and examples*
S-9	SLO-1	*Map representation*	*Kalman filter design*			*Application case study for EKF based SLAM*
	SLO-2	*Types*	*Kalman filter design*			*Application case study for EKF based SLAM*
S-10	SLO-1	*Types and comparison of map representation strategies*	*Kalman matrices*			*Application case study for Particle Filter based SLAM*
	SLO-2	*Types and comparison of map representation strategies*	*Sensor fusion using Kalman filter*			*Application case study for Particle Filter based SLAM*

Learning Resources	1. *Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 2nd Edition, Springer, 2016.* 2. *Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011.*	3. *Perter Corke, "Robotics, Vision and Control", 2nd Edition, Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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

Course Code	18MHE461T	Course Name	ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND VISION	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 :	*Obtain motivation for artificial intelligence and machine learning in robotics and vision*
CLR-2 :	*Appreciate the mathematics behind artificial intelligence*
CLR-3 :	*Understand the idea behind fuzzy logic for decision making*
CLR-4 :	*Understand the basics neural networks and deep learning philosophy*
CLR-5 :	*Get exposed to convolutional neural networks and its applications to vision guided robotics tasks*
CLR-6 :	*get awareness of deep neural networks for sequence modelling and reinforcement learning*

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO - 3
CLO-1 :	*Formulate the mathematical basics of fuzzy and neural networks*	*3*	*80*	*75*	*H*	*H*	*M*	*L*	*L*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-2 :	*Apply fuzzy logic problems to robotics applications*	*3*	*85*	*80*	*H*	*H*	*M*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-3 :	*Develop neural networks for simple classification tasks*	*2*	*70*	*65*	*H*	*M*	*L*	*M*	*L*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-4 :	*Exhibit conversant skill and knowledge with deep learning philosophy and training concepts*	*2*	*75*	*70*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-5 :	*Implement convolutional neural networks for simple computer vision tasks*	*2*	*85*	*80*	*H*	*M*	*M*	*M*	*M*	*-*	*-*	*-*	*M*	*L*	*-*	*L*	*H*	*M*	*-*
CLO-6 :	*Implement deep recurrent neural networks and reinforcement network for simple robot guidance tasks*	*2*	*80*	*75*	*H*	*M-*	*M*	*M*	*M*	*-*	*-*	*-*	*L*	*L*	*-*	*L*	*H*	*M*	*-*

		Introduction	Fuzzy Logic	Classical Neural Networks	CNN	RNN and Reinforcement Learning
Duration (hour)		8	10	10	8	10
S-1	SLO-1	*Introduction to artificial intelligence (AI)*	*Introduction to Fuzzy sets*	*Overview of biological neuro-system*	*Conventional neural networks vs. Deep learning in the context of computer vision*	*Unfolding computational graphs*
	SLO-2	*Intelligent agent*	*Classical and Fuzzy sets*	*Mathematical models of neurons*	*Support vector machine*	*Unfolding computational graphs*
S-2	SLO-1	*Categorization of AI*	*Overview of classical sets*	*ANN architecture*	*Numerical example*	*Recurrent neural networks*
	SLO-2	*Overview of different forms of learning*	*Membership function*	*Learning rules*	*Softmax*	*Deep recurrent networks*
S-3	SLO-1	*Overview of different forms of learning*	*Fuzzy rule generation*	*Learning paradigms*	*Numerical example*	*Long Short Term Memory (LSTM)*
	SLO-2	*Statistical decision theory*	*Fuzzy rule generation*	*Supervised, unsupervised semi-supervised and reinforcement Learning*	*Numerical example*	*Long Short Term Memory*
S-4	SLO-1	*Regression*	*Operations on fuzzy sets*	*Multi-layer perceptrons*	*Convolutional neural networks*	*Autoencoders*
	SLO-2	*Regression*	*Numerical examples*	*Multi-layer perceptrons*	*Convolution, pooling*	*Applications of autoencoders*
S-5	SLO-1	*Numerical problems*	*Fuzzy Arithmetic*	*Numerical problems based on perceptron*	*Activation functions*	*Reinforcement learning numerical example*
	SLO-2	*Numerical problems*	*Numerical examples*	*Numerical problems based on perceptron*	*Initialization*	*Reinforcement learning numerical example*
S-6	SLO-1	*Evaluation of learning algorithms and cross-validation*	*Fuzzy Logic*	*Backpropagation*	*Deep learning hardware*	*Deep reinformcement learning, Motivation*
	SLO-2	*Evaluation of learning algorithms and cross-validation*	*Fuzzification*	*Backpropagation*	*CPU, GPU, TPU*	*Examples for reinforcement learning*

S-7	SLO-1	*Applications of AI in robotics*	*Fuzzy sets*	*Numerical problems for back propagation*	*Best practices in training*	*Markov decision process*
	SLO-2	*Applications of AI in robotics*	*Defuzzification*	*Numerical problems for back propagation*	*Training neural networks*	*Major components of RL*
S-8	SLO-1		*Application case study for manipulator robotics application*	*Introduction of neuro-fuzzy systems*	*Data augmentation*	*Q-learning*
	SLO-2		*Application case study for manipulator robotics application*	*Introduction of neuro-fuzzy Systems*	*Transfer learning*	*Numerical example*
S-9	SLO-1		*Application case study for mobile robotics application*	*Architecture of neuro-fuzzy Networks*		*Deep Q-learning (DQN)*
	SLO-2		*Application case study for mobile robotics application*	*Architecture of neuro-fuzzy Networks*		*DQN training, best practices*
S-10	SLO-1			*Numerical example for neuro-fuzzy system*		*Application case study for deep reinforcement learning*
	SLO-2			*Numerical example for neuro-fuzzy system*		*Application case study for deep reinforcement learning*

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

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*30 %*	-	*30 %*	-	*30 %*	-	*20 %*	-	*40%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*30%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*40 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

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Course Code	18MHE462T	Course Name	SYSTEMS ENGINEERING AND MANAGEMENT FOR 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 :	*Understand the foundations of systems engineering*
CLR-2 :	*Recognize the conflicting requirements of modern engineering systems like robots and their life cycle stages through some relevant case studies and appreciate the need for system engineering*
CLR-3 :	*Gain sound knowledge on technical ,management, organizational and tailoring processes involved in system engineering and their analysis*
CLR-4 :	*Comprehend the cross-cutting system engineering methods and activities*
CLR-5 :	*Apply the knowledge of system engineering to solve the problems associated with complex engineering systems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1 Level of Thinking (Bloom)	Learning 2 Expected Proficiency (%)	Learning 3 Expected Attainment (%)	PLO 1 Engineering Knowledge	PLO 2 Problem Analysis	PLO 3 Design & Development	PLO 4 Analysis, Design, Research	PLO 5 Modern Tool Usage	PLO 6 Society & Culture	PLO 7 Environment & Sustainability	PLO 8 Ethics	PLO 9 Individual & Team Work	PLO 10 Communication	PLO 11 Project Mgt. & Finance	PLO 12 Life Long Learning	PLO 13 PSO - 1	PLO 14 PSO - 2	PLO 15 PSO - 3
CLO-1 :	*Familiarize the foundations of systems engineering*	2	75	70	H	H	M	H	M	-	-	-	-	-	-	H	H	H	H
CLO-2 :	*Identify the conflicting requirements of modern engineering systems and their life cycle stages*	3	75	70	H	H	M	H	M	-	M	-	-	-	-	H	M	M	M
CLO-3 :	*Acquire knowledge on technical ,management, organizational and tailoring processes involved in system engineering*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-4 :	*Realize the cross-cutting system engineering methods and activities*	3	75	70	H	H	M	H	M	-	M	M	-	-	M	H	M	M	M
CLO-5 :	*Apply the knowledge of system engineering to solve the problems in robotics and other complex engineering systems*	3	75	70	H	H	M	H	H	-	M	M	-	-	M	H	M	M	M

		Foundations of Systems Engineering (SE) and Life Cycle Stages	Technical Process of Systems Engineering	Management Process of Systems Engineering	Organizational and Tailoring Processes and Applications of System Engineering	Cross-cutting SE Methods and Activities
Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction, definition and concepts of systems*	*Business or Mission Analysis Process*	*Project planning process*	*Life cycle model management process*	*Modeling and simulation*
	SLO-2	*The hierarchy within a system*	*Stakeholder needs and requirements*	*Project assessment and control process*	*Infrastructure management process*	*Modeling and simulation*
S-2	SLO-1	*Definition of systems of systems*	*System requirements Definition Process*	*Decision management process*	*Portfolio management process*	*Model based system engineering*
	SLO-2	*Enabling systems and definition of Systems Engineering(SE)*	*System requirements Definition Process*	*Decision management process*	*Human resource management process*	*Model based system engineering*
S-3	SLO-1	*Origins and Evolution of system engineering*	*Architecture definition process*	*Risk management process*	*Quality management process*	*Function-based system engineering*
	SLO-2	*Use and value of system engineering*	*Architecture definition process*	*Risk management process*	*Knowledge management process*	*Object-oriented system engineering*
S-4	SLO-1	*System science and system thinking*	*Design definition process*	*Configuration management process*	*Tailoring process*	*Prototyping, Interface management*
	SLO-2	*System engineering leadership and professional development*	*Design definition process*	*Configuration management process*	*Tailoring process*	*Integrated product and process development*
S-5	SLO-1	*Introduction to Life cycle and its characteristics*	*System analysis process*	*Information management process*	*Tailoring for Automotive systems, Biomedical and healthcare systems*	*Integrated product and process development*
	SLO-2	*Life cycle stages*	*Implementation process*	*Information management process*	*Tailoring for defense and aerospace systems*	*Lean and agile system engineering*
S-6	SLO-1	*Life cycle approaches*	*Integration process*	*Measurement Process*	*Tailoring for infrastructure systems*	*Affordability analysis*

	SLO-2	*Life cycle approaches*	*Verification process*	*Measurement Process*	*Tailoring for space systems and ground transportation systems*	*Electromagnetic compatibility*
S-7	SLO-1	*Deciding what is best for organization, project or team*	*Transition process*	*Quality assurance process*	*Application of SE for product line management*	*Environmental /impact analysis, interoperability analysis*
	SLO-2	*Case study-1 Design for safety-Radiation therapy*	*Validation process*	*Quality assurance process*	*Application of SE for product line management*	*Logistics, manufacturing and producibility analysis*
S-8	SLO-1	*Case study-2 Need for prototyping system-Super high speed train in China*	*Operation process*	*Agreement process-introduction*	*Application of SE for services*	*Reliability and maintainability*
	SLO-2	*Case study -3 Cyber security considerations-The stuxnet attack*	*Maintenance process*	*Acquisition process*	*Application of SE for services*	*Resilience engineering*
S-9	SLO-1	*Case study-4 Design for maintainability-Incubators*	*Disposal process*	*Acquisition process*	*Application of SE for Enterprises*	*System safety and security engineering*
	SLO-2	*Concluding remarks on necessity of SE by relating to the above case studies*	*Concluding remarks on technical process*	*Supply process*	*Application of SE for small and micro enterprises*	*Value engineering*

Learning Resources	1. *David D.Walden, Garry J.Roelder, Kevin J.Forsberg, R.Douglas Hamelin, Thomas M.Shortell., "INCOSE Systems Engineering Handbook- A Guide for System Life Cycle Processes and Activities", 4th Edition, Wiley, 2015* 2. *Kossiakoff, A. Sweet, Seymour, S., W.N., Biemer, S.M., "Systems Engineering Principles and Practice", 2nd Edition, John Wiley & Sons, 2011.*	3. *Charles S.Wassen., "System Engineering Analysis, Design and Development" Wiley, 2016.* 4. *Blanchard, B.S. and Fabrycky, W.J., "Systems Engineering and Analysis", 4th Edition, Prentice Hall, 2005.* 5. *Zeigler, B.P., H. Praehofer, T.G. Kim., "Theory of Modeling and Simulation", 2nd Edition, Academic Press, 2000.*

Learning Assessment

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		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
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Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*30 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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