ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 24
Syllabi for School of Electrical Engineering Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Automation and Robotics

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIC551J	Course Name	FUNDAMENTALS OF ROBOTICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide foundational knowledge of robotic components, kinematics, and dynamics essential for understanding and designing basic robotic systems*
CLR-2:	*integrate and control of sensors and actuators, which are crucial for robots to interact effectively with their environment.*
CLR-3:	*introduce motion planning and control algorithms, enabling precise and efficient robotic movement.*
CLR-4:	*introduce computer vision principles and techniques necessary for developing vision-based autonomous robotic systems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the fundamental components and principles of robotics and gain skills in kinematic and dynamic analysis.*	2		
CO-2:	*identify, integrate, and control various sensors and actuators in robotic systems.*	3		
CO-3:	*apply kinematic and dynamic models, implement path planning algorithms, and develop control systems for accurate robotic motion.*	3	1	
CO-4:	*implement image processing algorithms, integrate vision systems with robotic control, and develop vision-based navigation systems.*	3	1	

Module-1 - Introduction to Robotics	***30 Hour***
Introduction to Robots, Robot Anatomy and Kinematics, DH methods, Robot Dynamics, Lagrangian and Newton-Euler methods *Experiments:* 1. *Basic robot kinematics simulation* 2. *Building of simple robotic arm* 3. *Control of robotic arm using basic algorithm*	
Module-2 – Sensors and Actuators in robotics	***15 Hour***
Sensors in Robotics, Actuators in Robotics, Signal Processing and Control *Experiments:* 1. *Sensor integration and data acquisition* 2. *Actuator control and performance analysis* 3. *Closed loop control system implementation*	
Module-3 – Robot Motion Planning and Control	***15 Hour***
Kinematic and Dynamic Modelling, Motion Planning Algorithm, Robot Control systems. *Experiments:* 1. *Path planning in simulation* 2. *Trajectory generation and execution* 3. *Implementing feedback control for motion accuracy*	

Module-4 - Robot Vision and Perception	***15 Hour***
Introduction to Computer Vision, Object Recognition and Localization, Applications of Vision in Robotics *Experiments:* *1. Basic image processing and feature extraction* *2. Object detection and recognition* *3. Vision guided robot navigation*	

Learning Resources		
	1. John J. Craig, "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson/Prentice Hall, 2017 *2. Mark W. Spong, Seth Hutchinson, M. Vidyasagar, " Robot Modeling and Control, 1st Edition, Wiley, 2005*	*3. Nikolaus Correll, Bradley Hayes, Magnus Egerstedt, " Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms ", 2nd Edition, MIT Press, 2022* *4. Richard Szeliski, "Computer Vision: Algorithms and Applications", 2nd Edition, Springer, 2022* *5. K. S. Fu, Ralph Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision and Intelligence", McGraw Hill Education, 2017*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. C. Likith Kumar, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIC552J	Course Name	INDUSTRIAL PROCESS AUTOMATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the components of automation system structure and different automation strategies*
CLR-2:	*introduce the PLC logic program for control application*
CLR-3:	*provide basic knowledge in SCADA and DCS in the field of automation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*select the appropriate I/O subsystem in automation system structure for process automation*	2		2
CO-2:	*develop the logic program for process control application*	3	2	
CO-3:	*apply the most appropriate automation technologies for a given application*	3	2	

Module-1 - Automation System Structure ***15 Hour***

Overview of Industrial Automation, Physical Processes, Localized and Distributed Processes, Process Behavior, Process Signals, Automation Steps, PLC control, panel wiring, Data Analysis, Monitoring, and Decision Making, Benefits of Automation, Subsystems, Input Instrumentation Subsystem, Output Instrumentation Subsystem, Human Interface Subsystem, Control Subsystem, Control Execution, Instrumentation Subsystem Structure, Signal Interfacing Standards, Input Data Reliability Enhancement, Isolation and Protection, Human Interface Subsystem, Operator Panel, Structure, Interfacing, Human Interface, Discrete Process Control, Continuous Process Control, Hybrid Process Control, Advanced Strategies, Continuous Control, Feed-Forward Control, Cascade Control, Ratio Control Multiple-Step Control, Programmable Control Subsystems, Soft-wired Technology, Automation Strategy Implementation, Sequential Control with Interlocks

Module-2 - PLC Programming and Troubleshooting ***30 Hour***

PLC size and application, Functional Components of a PLC, Internal Architecture, Input Devices, Output Devices, Ladder Programming, Cascading timer, counters, Cascading Counter, Combining counter and timer functions, Data compare, Math instructions, Function Block Programming, Instruction Lists, Sequential Function Charts, Structured Text Programming Method, Commissioning, Troubleshooting PLC hardware

1. *Study of PLC Market survey on different PLC's, and its comparison*
2. *Development of control logic for filling and draining of liquid in a single tank*
3. *Development of control logic for Material handling*
4. *Development of control logic for automatic Bottle filling process*
5. *Development of control logic for Temperature control*
6. *Development of control logic for Flow control*
7. *Development of control logic for Lift control*
8. *Development of control logic for Car parking*
9. *Study the working of DCV's Development of control logic for Stamping machine control*

Module-3 - SCADA and DCS ***30 Hour***

SCADA basics, Elements of SCADA, Functionality of SCADA, History of SCADA, Analog signals measurement, Control techniques, Discrete signals measurement, Control techniques, Remote terminal unit, Analog and Discrete control, Monitoring signals, Master terminal unit, Communication system components, Field/RTU communication, Communication Topology, RTU/MTU communication, System components, Monitoring alarms, Status points, Control interfacing, Parallel operator interface, Evolution of Distributed Control System, DCS Architecture, Local control unit, Architectural parameters, Operator interface, Operator Interface Requirements, Operator input-output devices, Low-level Operator Interface, Operator displays, Engineering interface- Introduction, Low-level engineering interface, High-level engineering interface, DCS Application in Power plant, Automation strategy, DCS Application in cement plant, System architecture, DCS Application in steel plant, System architecture. 1. *SCADA Development for the level process control training plant* 2. *SCADA Development for the flow process control training plant* 3. *SCADA Development for the temperature process control training plant* 4. *DCS control panel wiring diagram and creating control panel layout Interfacing level transmitter to a DCS* 5. *On line monitoring and control of level process using DCS* 6. *A mini project in process automation*

Learning Resources	1. *KLS Sharma "Overview of Industrial Process Automation" Elsevier, Second edition, 2017.* 2. *Frank D. Petruzella, "Programmable Logic Controller",Tata McGraw Hill 5th Edition, 2017.* 3. *B.R. Mehta, Y. J. Reddy "Industrial Process Automation Systems Design and Implementation" Elsevier, 2015 ".* 4. *Stuart Boyer A, "SCADA : Supervisory control and data Acquisition", Fourth Edition, ISA-The Instrumentation, Systems, and Automation Society, 2010*	5. *IDC Technologies, "Practical Distributed Control Systems (DCS) for Engineers and Technicians"2012.* 6. *NPTEL Video Lecture series on "Industrial Automation and Control "by Prof. S. Mukhapadhyay, IIT Kharagpur* 7. *Moustafa Elshafei," Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards", CreateSpace Independent Publishing Platform, 2016*

Learning Assessment

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

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. G. Joselin Retna Kumar, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIC553J	Course Name	ROBOT PROGRAMMING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduces students to foundational concepts in robot programming*
CLR-2:	*covers advanced topics in robot autonomy, emphasizing slam for mapping and localization, techniques*
CLR-3:	*explores topics in multi-robot systems, object tracking, and human-robot interaction*
CLR-4:	*addresses advanced topics in human-robot interaction HRI), dynamic path planning, and advanced kinematics.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain proficiency in writing ROS nodes for robot movement, implementing algorithms*	*2*		
CO-2:	*develop the ability to apply SLAM algorithms to create maps and localize robots accurately*	*3*		
CO-3:	*implement object tracking algorithms, and design intuitive HRI interfaces for effective human-robot collaboration.*	*3*	*1*	
CO-4:	*acquire skills in developing interactive interfaces for HRI using voice and gesture recognition, implementing dynamic path planning algorithms*	*3*	*1*	

Module-1 - Basics of Robot Programming and Movement	***15 Hour***
Introduction to ROS, Basic Robot Control, Line Following Algorithm, RoboAnalyzer *Experiments:* 1. *Basic movement* 2. *Obstacle avoidance* 3. *Line following robot*	
Module-2 - Mapping, Localization, and Navigation	***15 Hour***
SLAM (Simultaneous Localization and Mapping), Localization Techniques, Vision Based Navigations *Experiments:* 1. *Mapping and localization* 2. *Autonomous navigation* 3. *Vision based navigation*	
Module-3 - Advanced Robot Interaction and Coordination	***15 Hour***
Multi-Robot Systems, Robotic Arm Control, Object Tracking and Following *Experiments:* 1. *Multiple robot coordination* 2. *Pick and Place with robotic arm* 3. *Follow the Leader*	

Module-4 – Human-Robot Interaction and Advanced Kinematics	***30 Hour***
Human Robot Interaction, Dynamic Path Planning, Advanced Kinematics *Experiments:* *1. Human Robot Interaction using voice and gesture* *2. Path planning in dynamic environment* *3. Implement inverse kinematics for complex robot configuration*	

Learning Resources	*1. Morgan Quigley, Brian Gerkey, and William D. Smart" Programming Robots with ROS", 1st Edition, O'Reily Media, 2015* *2. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011*	*3. Adrian Kaehler and Gary Bradski, "Learning OpenCV 3: Computer Vision in C++ with the OpenCV Library", 1st Edition, O'Reily Media, 2016* *4. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, "Robot Modeling and Control", 1st Edition, Wiley, 2005* *5. Cameron Hughes, Tracey Hughes, "Robot Programming: A Guide to Controlling Autonomous Robots", Pearson Education, 2016*

Learning Assessment

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. C. Likith Kumar, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

ACADEMIC CURRICULA

Automation and Robotics & Electronics and Control Engineering

Common Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIC504J	Course Name	REAL TIME EMBEDDED SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

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

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	impart the knowledge on the basic concepts of embedded processor
CLR-2:	learn the programming techniques in ARM processor
CLR-3:	know the steps involved in designing an embedded system
CLR-4:	introduce the real time scheduling algorithms

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	understand the evolution and architectures of ARM processors	1		
CO-2:	develop programming skill for ARM processor	1		2
CO-3:	analyze the instruction set and develop program for real world problems	1		2
CO-4	apply the knowledge of embedded system in real time application	1	1	3

Module-1 - Embedded Processor **20 Hour**

Review of Embedded Computing; Interfacing sensors embedded system design process; CPS and embedded Computing Architecture of ARM Cortex M3 and Cortex A series processors; ARM tool-chain for compilation, linking and execution phases; Memory system mechanism; Cache; Memory management units and address translation; Performance assessment of embedded processor; Introduction to Embedded Multicore Architecture; ARM virtual hardware: capabilities and use; QEMU for ARM processors

Practice:

1. *Interfacing sensors*
2. *Interfacing LED.*
3. *Interfacing DAC, ADC*
4. *Interfacing DIO, PWMs*

Module-2 - Programming **18 Hour**

Introduction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations, CortexM4-specific instructions, Thumb2 instructions, Programming of Embedded processors using assembly and C; models for program -- data flow graphs; Assembly language programming of ARM Cortex M3; Hardware software co-design

Practice:

1. *Interfacing keyboard*
2. *Interfacing stepper motor*
3. *Interfacing Temperature sensor*
4. *Interfacing potentiometer sensor*
5. *Interfacing electrical switches*

Module-3 – System Design	***18 Hour***
Design methodologies, Design flows, Requirement analysis, Multiple tasks and multiple processes, Preempt real time operating systems, Priority based scheduling, Distributed embedded systems, Examples of distributed embedded systems in industries, Wireless based embedded systems *Practice:* *1. Interfacing process (time-driven)* *2. Interfacing event schedule* *3. Debugging : Learn to find faults in a system* *4. Tracing : Understand instruction set logs, derive problem loops*	
Module-4 – Applications	***19 Hour***
Processes and real time operating systems; Multi-rate system; real time scheduling algorithms - RMA,EDF and their variants; Energy efficient scheduling algorithms; Data compression techniques, Examples of design of embedded systems. Architecture security features, Arm Confidential Compute Architecture (Arm CCA) – an isolation technology that builds on the strong security foundations of TrustZone- AUTOSAR ECUs with ARM processors : Next generation HPCs and Zonal ECUs *Practice: 1. Communication between MSPs ,2. Networking MSPs using Wi-Fi , 3. Smart automation*	

Learning Resources		
	1. Marilyn Wolf,, High Performance embedded Computing: Applications in Cyber Physical Systems and Mobile Computing, 2 nd Edition, Elsevier 2014 *2. JosephYiu,, The definitive Guide to ARM Cortex M3 and M4 Processors, 3 rd Edition, Elsevier 2020* *3. Ata Elahi-Trever Arjeski, ―ARM Assembly language with hardware experiment‖, Springer Int. Publishing, 2016.*	*4. William hohl and Christoper Hinds, ―ARM assembly language fundamentals and Techniques ‖CRC, 2 nd edition,2015.* *5. Marilyn Wolf, Computers as Components: Principles of Embedded Computing System Design, Third Edition, Elsevier 2022* *6. Daniel Kusswurm, Modern Arm Assembly Language Programming, Apress, 2020*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. N. Natarajan, M.Eng., ETAS GmbH	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.J.Sam Jeba Kumar, SRMIST*
2. Himanshu Shekhar ,L&T Energy	*2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIC505T	Course Name	ARTIFICIAL INTELLIGENCE IN AUTOMATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of AI-driven automation*
CLR-2:	*explore the principles of IA technologies*
CLR-3:	*learn about AI techniques implemented for intelligent automation in real world applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the concepts of Intelligent Automation*	*1*	*1*	-
CO-2:	*demonstrate proficiency in AI techniques for Intelligent Automation.*	*2*	-	-
CO-3:	*interpret the AI techniques for Automation in real world applications for SDGs*	*3*	*2*	*2*

Module-1 – Introduction to Intelligent Automation	***15 Hour***
Evolution of Automation, stages of automation, Sustainability Development Goals and automation, Introduction to Artificial Intelligence- key concepts and Principles, Artificial Intelligence in industries, Introduction to Intelligent Automation (IA) - its principles, applications, and impact on industries, components of intelligent automation technology, Examples of intelligent automation, Understanding IA, Differentiation of IA with AI, Impact of Automation in Enterprise	
Module-2 – IA technologies	***15 Hour***
Robotic Process Automation (RPA), Business Process Management, Business Intelligence, IA technologies Framework - Vision, Execution, Language, Thinking and Learning, Challenges in implementing IA, Chatbots and Virtual Assistants, Applications of IA technologies framework in various industries, intelligent automation techniques for environmental monitoring, intelligent *automation for optimizing renewable energy systems, grid integration*	
Module-3 – AI techniques for Automation and SDGs	***15 Hour***
Overview of key AI techniques applicable to automation processes - Supervised, unsupervised, and reinforcement learning techniques for automating decision-making processes, Techniques for processing and understanding human language in automation systems, Applications of NLP in automated customer service, chatbots, and text analytics, Integration of AI techniques with robotics for automation of physical tasks, Reinforcement learning for robotic control and motion planning, Introduction to Sustainability Development Goals (SDGs). Intelligent Automation and Sustainability; intelligent automation for precision agriculture; intelligent automation for sustainable urban planning	

Learning Resources	1. *Debanjana Das Gupta, Intelligent Automation Simplified - BPB Publications, 2022.* 2. *Bornet, P, Barkin, I. and Wirtz, J., Intelligent automation: welcome to the world of hyper automation: Learn How to Harness Artificial Intelligence to Boost Business & Make Our World More Human, World Scientific Publishers, 2021*	3. *R. Arumugam et al, Hands-On Natural Language Processing with Python: A practical guide to applying deep learning architectures to your NLP applications, Packt Publishers, 2018* 4. *Pascal Bornet, Pascal. Barkin Bornet, Ian Barkin, Jochen Wirtz, "Intelligent Automation", World Scientific, 2020*

Learning Assessment

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

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.Sridhar P.A. SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

ACADEMIC CURRICULA

Automation and Robotics

Professional Elective Courses

Regulations 2021

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIE551T	Course Name	COMPUTER VISION AND IMAGE PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of robotic vision sensors and sensor interfacing.*
CLR-2:	*analyze position, orientation, and localization of objects.*
CLR-3:	*analyze the machine learning concepts for recognition and interpretation of robotic vision.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the knowledge to select the appropriate robotic vision sensor and their interfacing.*	3		
CO-2:	*ability to position, orientation and localization of objects using deep learning networks for solving tasks.*	3		2
CO-3:	*evaluate the performance of machine learning models using appropriate metrics and interpret the results of robotic sensors.*	2	2	2

Module-1 - Robotic Vision Sensors and Their Interfacing	***14 Hour***
Formation, Filtering, Transformation, Image Restoration, morphing, Camera Models, Calibration, Single view geometry, Multiple view geometry, Epipolar geometry, RANSAC, Segmentation, Feature Description and Matching, Deep Learning based Segmentation.	
Module-2 - Position and Orientation	***17 Hour***
Feature based alignment; Pose estimation; Time varying pose and trajectories, Structure from motion, dense Motion Estimation, Visual Odometry (Semi-direct VO, direct sparse odometry), Bundle Assignment, Localization and Mapping: Initialization, Tracking, Mapping, geometric SLAM formulations (indirect vs. direct error formulation,geometry parameterization, sparse vs. dense model, optimization approach), Relocalization and map Optimization, Visual SLAM, Examples: Indirect (Feature based) methods (MonoSLAM, PTAM, ORB-SLAM), Direct methods (DTAM, LSD-SLAM), Sensor combinations (IMU, mono vs. Stereo, RGB-Depth.	
Module-3 - Recognition and Interpretations	***14 Hour***
Concepts of machine learning and deep learning, sequence modeling, Learning for robotic vision: Active learning, incremental and class incremental learning identify unknowns, uncertainty estimation, Embodiment for robotic vision: active vision, spatial and temporal embodiment, reasoning for object, scene and scene semantics.	

Learning Resources		
	1. Rajalingappaa Shanmugamani , Deep Learning for Computer Vision, Packt Publishing, 2018 *2. S. R. Deb, Sankha Deb, Robotics Technology and Flexible Automation, 2nd edition, McGraw Hill Education, 2017.* *3. Abdessalan Bouzerdoum, George Mamic and M. Bennamoun, Object Recognition:Fundamentals & Case Studies, First Edition, Universities Press, 2008*	*4. Goodfellow, Y, Bengio, A. Courville, "Deep Learning", MIT Press, 2016.* *5. Dahiya, Ravinder S., Valle, Maurizio, Robotic Tactile Sensing, Springer, 2013.* *6. Milan Sonka, Vaclav Hlavac and Roger Boyle, Image Processing, Analysis and Machine Vision, Cengage, Third Edition (2013)*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1.Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. A. Brindha, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE552T	Course Name	CYBER SECURITY IN INDUSTRIAL AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic knowledge in industrial automation and control systems*
CLR-2:	*understand the difference between IACS and IT paradigms*
CLR-3:	*explore the security methodologies and approaches for IACS*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the basic concepts of industrial automation and control systems*	*3*		*2*
CO-2:	*illustrate any application with add-on security features in industrial control systems*	*3*		*2*
CO-3:	*develop the security methodologies for industrial systems*	*3*		*2*

Module-1 - Fundamentals of Industrial Automation and Control Systems	***15 Hour***
IACS – Introduction - SCADA systems - Distributed control systems - Safety instrumented systems IACS – Protocol - OSI model - TCP/IP model - OPC for process control - TCP, DNP3 protocol - Utility communication architecture – Profibus - Controller area network - Ethernet/IP - Open safety protocol - Issues in IACS security - Information security - Approaches of information security - Applications	
Module-2 - IACS Culture Versus IT Paradigms	***15 Hour***
Information system security fundamentals -Terminologies - Threat matrix - Type and classes of attack - Additional system security - Policies, standards - Guidelines and procedures - Malicious codes and attacks – Firewalls – Cryptography - Digital signatures - Attacks against cryptosystems - Virtual private network – IPsec - Transport mode - Tunnel mode - Secure sockets layer - Physical and economic damage - Differences in culture, philosophy, and requirements - Comparison between IT and IACS issues - Considerations in adapting IT security methods to IACS - Threats and motivations for attackers - Threat sources - Technological trends - Smart grid and its trends - Smart grid protocols - Mapping of emerging technology - Example automation system	
Module-3 - Cyber Security Design and Implementation	***15 Hour***
Risk management - Risk relationships - Cybersecurity management systems - Monitoring and improving the IACS - Integrated enterprise risk management - Guide for applying risk management framework - Insider threat -Threat example – Stuxnet - Defensive approaches - Electromagnetic pulse – HEMP - Protection measures - Standards – IEC & IEEE Cyber security lifecycle - Conceptual design process - Firewall design - Intrusion detection design - Security standards, Guidelines - NIST – Guide to ICS security, Management controls - ANSI/ISA security technologies, - Encryption technologies, Physical security controls - NERC – Critical infrastructure protection - Security management controls -Personal and training - Electronic security - Physical security of critical cyber assets - Recovery plans	

Learning Resources		
	1. *Steve Mustard, "Industrial Cybersecurity: Case Studies and Best Practices", ISA, 2022.* 2. *Charles J. Brooks, Philip A. Craig Jr." Practical Industrial Cybersecurity", Wiley, 2022.* 3. *K S Manoj, Cyber Security : in industrial automation, Notion Press, 2020.*	4. *Ronald L. Krutz, "Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure", 2nd ed., ISA, 2017.* 5. *Perry S.Marshall. "Industrial Ethernet", ISA, 2017.* 6. *Edward J,M.Colbert, "Cyber Security of SCADA and other Industrial Control Systems" , Springer, 2016*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. G.Y.Rajaa Vikhram, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE553T	Course Name	INDUSTRIAL DATA COMMUNICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of data communication in industrial environments.*
CLR-2:	*learn about wireless communication technologies and their applications in industrial settings.*
CLR-3:	*analyze case studies and real-world examples of industrial data communication systems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain knowledge of industrial communication protocols and standards.*	3	-	-
CO-2:	*explore cyber security challenges and solutions in industrial data communication.*	3	-	-
CO-3:	*analyze the data communication systems in various domain applications.*	3	-	2

Module-1 – Fundamentals of Networking for Industrial Applications	***15 Hour***
Introduction to Industrial Data Communication- Overview of industrial automation systems-Importance of data communication in industrial environments- Challenges and requirements for industrial data communication- Fundamentals of Networking for Industrial Applications- Network architectures and topologies- Wired and wireless communication technologies- Ethernet-based industrial networks	
Module-2 – Industrial Communication Protocols	***15 Hour***
Industrial Communication Protocols- Fieldbus protocols (e.g., Profibus, Modbus, DeviceNet)Ethernet-based protocols (e.g., EtherNet/IP, PROFINET)-Time-sensitive networking (TSN) standards -Wireless Communication in Industrial Environments- Wireless sensor networks (WSNs)-Industrial Wi-Fi standards (e.g., IEEE 802.11)-Wireless HART and ISA100.11a protocols- Industrial Internet of Things (IIoT) and Industry 4.0 Concepts and principles of IIoT- Integration of sensor networks and cloud computing- Role of data analytics in industrial applications	
Module-3 – Cybersecurity in Industrial Data Communication and Case studies	***15 Hour***
Cyber security in Industrial Data Communication- Threats and vulnerabilities in industrial networks- Security protocols and mechanisms (e.g., VPNs, firewalls)-Defense-in-depth strategies for industrial cyber security- Case Studies and Practical Applications- Real world examples of industrial data communication systems- Analysis of implementation challenges and solutions- Industry-specific use cases (e.g., manufacturing, energy, transportation)	

Learning Resources		
	1. *Richard Zurawski, "Industrial Communication Technology Handbook" CRC Press, 2014.* 2. *Perry S. Marshall , "Industrial Ethernet: How to Plan, Install, and Maintain TCP/IP Ethernet Networks", John Wiley & Sons, 2004.*	3. *Subhabrata Ghosh,"Wireless Communication in Underground Mines: RFID-based Sensor Networking", CRC Press, 2018.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. Jekan P SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE554T	Course Name	MACHINE LEARNING AND DATA ANALYTICS	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	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

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Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of machine learning and the essential tools to decipher patterns and make predictions from complex datasets.*
CLR-2:	*learn about data preprocessing and feature engineering to extract meaningful information*
CLR-3:	*know about neural networks and deep learning algorithms to tackle intricate problems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply various machine learning algorithms to analyze complex datasets and make accurate predictions.*	*3*	*1*	*-*
CO-2:	*demonstrate proficiency in data preprocessing techniques, including cleaning, transformation, and normalization, to prepare data for analysis.*	*2*	*-*	*2*
CO-3:	*develop the skills to design and implement neural networks and deep learning networks for solving tasks.*	*3*	*1*	*2*

Module-1 – Machine Learning Algorithms	***15 Hour***
Introduction to Machine Learning - types of learning (supervised, unsupervised, reinforcement, Linear Regression, Logistic Regression, Decision Trees and Random Forest, Introduction to Support Vector Machines (SVM) and practical applications, Naive Bayes algorithm, conditional probability, Clustering Algorithm - K-means clustering, hierarchical clustering, and density-based clustering, Dimensionality Reduction, Performance Metrics - Common metrics such as accuracy, precision, recall, F1 score, ROC-AUC curve, mean squared error (MSE), and silhouette score, Bias-Variance Tradeoff	
Module-2 –Neural Networks and Deep Learning Networks	***15 Hour***
Introduction to Neural Networks: Feedforward Neural Networks (FNNs); Training FNNs using gradient descent and backpropagation. Convolutional Neural Networks (CNNs), Architecture and design principles of CNNs for image classification, object detection, and segmentation tasks. Recurrent Neural Networks (RNNs), Introduction to Deep Learning Architectures, the principles and applications of these architectures in various domains, including computer vision, and robotics. Deep Learning Frameworks - Overview of popular deep learning frameworks such as TensorFlow, PyTorch, and Keras. Model Evaluation Techniques and Model Selection Criteria	
Module-3 – Data Analytics and Techniques	***15 Hour***
Data Cleaning, data transformation; Data Imputation, Handling Categorical Data, Feature Engineering, Date and Time Data Handling, Data Normalization, Handling Skewed Data, Data Integration: Combining multiple datasets for analysis, Exploratory Data Analysis (EDA), Descriptive statistics, Data visualization, Correlation analysis, Decision Support Systems	

Learning Resources		
	1. *Giuseppe Bonaccorso, Machine Learning Algorithms: Popular algorithms for data science and machine learning, Second Edition, Packt Publishing, 2018*	4. *Exploratory Data Analysis – John Hopkins University Coursera, https://www.coursera.org/learn/exploratory-data-analysis*
	2. *Ian Goodfellow, Yoshua Bengio & Aaron Courville, Deep Learning, MIT Press, 2016.*	5. *Python for Data Science (IIT Madras); NPTEL, https://onlinecourses.nptel.ac.in/noc22_cs32/preview*
	3. *Tom M. Mitchell, Machine Learning, , McGraw Hill, 2017*	

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.Sridhar P.A. SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE555T	Course Name	EMBEDDED AUTOMATION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of embedded automation systems.*
CLR-2:	*integrate various sensors and actuators in automation systems.*
CLR-3:	*explore advanced topics in automation including iot and machine learning*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*design and implement automation solutions using embedded systems*	3	-	-
CO-2:	*develop embedded software for automation applications*	3	-	-
CO-3:	*apply IOT and Machine learning in automation systems.*	3	-	2

Module-1 – Microcontrollers and Embedded Processors	***15 Hour***
Introduction to Embedded Automation System, Overview of automation systems, Role of embedded systems in automation, Applications of automation in various industries, Architecture and features of microcontrollers (ARM, AVR, PIC),Embedded processors and their applications in automation, Programming microcontrollers for automation tasks, Sensors and Actuators in Automation, Types of sensors used in automation, Interfacing sensors with microcontrollers, Types of actuators and their control mechanisms, Integration of sensors and actuators in embedded systems, Control Strategies for Automation, Introduction to control theory, PID control and its application in automation, Advanced control strategies (adaptive, predictive control),Practical implementation of control algorithms	
Module-2 – Communication Protocols and RTOS	***15 Hour***
Serial communication (UART, SPI, I2C),Industrial communication protocols (Modbus, CAN, Ethernet/IP),Wireless communication protocols (Zigbee, Bluetooth, Wi-Fi),Networking and communication in automation systems, Real-Time Operating Systems (RTOS),Basics of real-time systems, RTOS concepts and applications, Task scheduling, synchronization, and communication, Implementing RTOS in automation projects	
Module-3 – Embedded Software Development for Automation	***15 Hour***
Embedded C/C++ programming, Software development lifecycle for embedded systems, Debugging and testing embedded automation systems, Code optimization for real-time performance Industrial Automation Systems, Overview of PLC systems, Integration of embedded systems with industrial automation, Case studies: Industrial automation applications, Introduction to IoT concepts IoT architecture and protocols, IoT-enabled automation systems, Machine Learning in Embedded Automation, Basics of machine learning, Applications of machine learning in automation, Implementing machine learning algorithms on embedded systems, Case studies: Predictive maintenance, anomaly detection	

Learning Resources	1. *James K. Peckol , "Embedded Systems: A Contemporary Design Tool" Wiley, 2008* 2. *Phillip A. Laplante, "Real-Time Systems Design and Analysis", Wiley, 4th edition, 2013*	*3. Frank Lamb, "Industrial Automation: Hands-On", Mc Graw Hill Education, 2013* *4 Richard Zurawski, "Embedded Systems Handbook", CRC press 2018.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in	1. Dr. Jekan P SRMIST
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE651T	Course Name	INTERNET OF ROBOTIC THINGS	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	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart in-depth knowledge on available architectures for internet of robotic systems.*
CLR-2:	*provide knowledge of several tools for the design of Robotic systems*
CLR-3:	*analyses of various Robotic Mobility Systems and their control algorithms.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*build appropriate architectures for robotic models based on need.*	*3*		
CO-2:	*design robotic systems with precision and validation systems.*	*3*	*2*	
CO-3:	*plan and design algorithms for robotic models for various fields.*	*3*	*2*	

Module-1 – Architecture and Platform	***15 Hour***
Introduction- Achievability of the Proposed Architecture, Qualities of IoRT Architecture, Reasonable Existing Robots for IoRT Architecture; Platforms- Cloud Robotics Platforms, IoRT Platform, Design a Platform, Components of the Proposed Approach, IoRT Platform Design, Interconnection Design; Research Methodology- Advancement Process, Systems Thinking, Development Process.	
Module-2 – Automated Verification and Validation of IoRT Systems	***15 Hour***
Introduction- Automating V&V; An Important Key to Success - Program Analysis of IoRT Applications, Need for Program Analysis, Aspects to Consider in Program Analysis of IoRT systems; Formal Verification of IoRT Systems, Automated Model Checking, Model Checking Process, PRISM, UPPAAL, SPIN Model Checker; Validation of IoRT Systems- IoRT Testing Methods, Design of IoRT Test, Automated Validation.	
Module-3 – Planning and Control Algorithms	***15 Hour***
General Architecture of IoRT- Hardware Layer, Network Layer, Internet Layer, Infrastructure Layer, Application Layer; Artificial Intelligence in IoRT Systems- Technologies of Robotic Things, Artificial Intelligence in IoRT; Control Algorithms and Procedures for IoRT Systems- Adaptation of IoRT Technologies, Multi-Robotic Technologies; Application of IoRT in Different Fields.	

Learning Resources		
	1. *R. Anandan , G. Suseendran , S. Balamurugan , Ashish Mishra , D. Balaganesh , 'Human Communication Technology: Internet-of-Robotic-Things and Ubiquitous Computing', Scrivener Publishing, 2022.* 2. *Arun Kumar Rana, Nitin Goyal, Sharad Sharma, Suman Lata Tripathi, "Internet of Things Robotic and Drone Technology, CRC Press, 2022.*	3. *Gurram Sunitha, J. Avanija, K. Reddy Madhavi, S. Bharath Bhushan, Sam Goundar, "Innovations in the Industrial Internet of Things (IIoT) and Smart Factory", IGI Global, 2021.* 4. *Anand Nayyar, Krishna Kant Singh, Mohamed Abouhawwash, Sudeep Tanwar, " Emergence of Cyber Physical System and IoT in Smart Automation and Robotics, Springer International Publishing, 2021*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.S. Sharanya SRMIST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE652T	Course Name	SMART MANUFACTURING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide the knowledge on the fundamentals of manufacturing and Industry 5.0*
CLR-2:	*know the key technologies, tools, and data acquisition techniques employed in Smart Manufacturing*
CLR-3:	*learn the challenges and opportunities associated with implementing Smart Manufacturing systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the different smart manufacturing technologies and Industry 5.0*	2	-	3
CO-2:	*use the key technologies in data acquisition techniques of Smart Manufacturing*	-	2	-
CO-3:	*analyze the challenges and opportunities associated with Smart Manufacturing*	-	-	3

Module-1 – Smart Manufacturing Techniques	***15 Hour***
Benefits of Smart Manufacturing - Evolution of manufacturing systems - Key components and technologies in Smart Manufacturing- Industrial Automation and Control Systems-Digitalization and the Networked Economy - Globalization - Emerging Trends - Intelligent control of machines - Computed Aided Quality Control - Digital Twin - Industrial IoT- Industry 5.0 - Principles & Objectives	
Module-2 –Smart Design and Fabrication	***15 Hour***
Smart Design/Fabrication - Digital Tools - Product Representation and Standards- Agile (Additive) Manufacturing Systems and Standards - Mass Customization - Smart Machine Tools- Smart Sensor networks and Devices - Online Predictive modeling - Monitoring and Intelligent Control of Machining/Manufacturing - Logistics/Supply Chain Processes-Smart Energy Management of manufacturing processes and facilities	
Module-3 – Applications and Sustainability	***15 Hour***
Smart manufacturing in Food Industry - Medical - Power Plants- Inventory Management & Quality - Sustainability and environmental considerations in Smart Manufacturing - Energy efficiency - Waste Reduction and Recycling - Resource optimization - Ethical and social implications of automation and AI - Emerging trends in Smart Manufacturing	

Learning Resources	1. *Masoud Soroush, McKetta Michael Baldea, & Thomas Edgar, Smart Manufacturing: Concepts and Methods, 1st Edition, Elsevier, 2020* 2. *Elangovan, Smart Automation to Smart Manufacturing: Industrial Internet of Things, 1st Edition, Momentum Press, 2019* 3. *Ponnambalam S G., Industry 4.0 and Hyper-Customized Smart Manufacturing Supply Chains, 1st Edition, IGI Global, 2020*	4. *Prof. R. K. Amit, Prof. U. Chandrasekhar, The Future of Manufacturing Business-Role of Digtal Technologies, IIt Madras,* 5. *https://onlinecourses.nptel.ac.in/noc21_mg83/preview*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Ravichandran, Technical Director, Senlogic group*	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. R.Bakiya lakshmi, SRMIST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE653T	Course Name	AUTONOMOUS MOBILE ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop problem-solving skills by applying principles of robotics engineering.*
CLR-2:	*communicate effectively about robotics engineering technologies, their workings and potential applications.*
CLR-3:	*demonstrate proficiency in robotics engineering for real-world problems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain knowledge of basic mechanical designing, electrical wiring, robotic sensors and actuators, PCB design and communication protocols.*	*3*		
CO-2:	*develop an understanding of the theoretical background necessary to understand advanced robotic technologies and their specific applications.*	*3*	*2*	
CO-3:	*demonstrate proficiency in design, construction, and operation of robotic systems.*	*3*	*2*	

Module-1 – Introduction to Mobile Robotics	***15 Hour***
Basics-Types of mobile robots, Degrees of freedom of mobile robots, Locomotion in mobile robots- legged mobile robots- leg configuration and stability, wheeled mobile robots- design space and case study, aerial mobile robots- aircraft configuration, sensors for mobile robots- sensor classification, characterizing sensor performance, wheel/ motor sensors, inertial motion sensors, accelerometers, speed sensors, vision sensors.	
Module-2 – Mobile Robot Kinematics	***15 Hour***
Kinematic models and constraints- representing robot position, forward kinematic models, wheel and robot kinematic constraints, mobile robot maneuverability- degree of mobility, degree of steerability, mobile robot workspace- degrees of freedom, holonomic robots, path and trajectory consideration- beyond basic kinematics- motion control – open loop control , feedback control,	
Module-3 – Perception in Mobile Robots	***15 Hour***
Computer vision- digital camera, image formation, omni-directional camera, structure from stereo & motion, color tracking, Image processing- image filtering, edge detection, computing image similarity- feature extraction – interest point detector, corner detectors, placer cognition, mobile robot localization- challenges of localization- noise and aliasing, belief representation- single and multiple hypothesis, map representation- continuous and decomposition strategies, map based localization, autonomous map building.	

Learning Resources	*1. Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza. Introduction to autonomous mobile robots. MIT press, 2011.* *2. S. K. Saha, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd., New Delhi.* *3. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Publishing Company Ltd.*	*4. M.W.Spong, S.Hutchinson and M. Vidyasagar, "Robot Modelling and Control", John Wiley & Sons Inc.,2006.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.S. Sharanya SRMIST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE654T	Course Name	MODELING AND CONTROL OF ROBOTIC SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the Mathematical Modelling of Robots and understand the robot design*
CLR-2:	*explore the concept of robot dynamics and the independent joint control*
CLR-3:	*gain the knowledge in multivariable control and force control of robotic system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*develop the Mathematical Modelling of Robots, Rigid motions, rotations, translations and homogenous transformations*	*3*		
CO-2:	*outline the structure of robot dynamics and the knowledge of independent joint control in robotic system*	*3*		
CO-3:	*apply the multivariable control and force control in robotic system*			*3*

Module-1 – Mathematical Modeling of Robots	***15 Hour***
Symbolic representation of robots-The configuration space, state space, workspace- Robots as mechanical devices- Classification of robotic manipulators- Robotic systems- Wrists and end effectors- Common kinematic arrangements- Articulated manipulator, spherical manipulator, SCARA manipulator, Cylindrical manipulator, Parallel manipulator- Rigid motions and homogeneous transformations- Representing positions, rotation in the plane, rotation in three dimensions, rotational transformations, similarity transformations- Rotation with respect to current frame, rotations with respect to fixed frame, rules for composition of rotational transformations- Parameterizations of rotations.	
Module-2 – Independent Joint Control	***15 Hour***
Actuator Dynamics, independent joint model, set point tracking- PD compensator, PID compensator - The effect of saturation and flexibility, feedforward control, drive train dynamics, state space design- State feedback control, control of driftless system- Dynamics - The Euler, Lagrange equations, kinetic and potential energy, properties of robot dynamic equations- Path planning using potential fields, Trajectory planning- Trajectories for point to point motion, trajectories for paths specified by via points- Velocity kinematics- Derivation of the Jacobian- Linear Velocity, angular Velocity.	
Module-3 – Multivariable Control and Force Control	***15 Hour***
Motion control- The Control Problem, Joint Space Inverse Dynamics, task space inverse dynamics, robust and adaptive motion control, centralized control, passivity based robust control, passivity based adaptive control- Force control - Manipulator interaction with environment, compliance control, impedance control, constrained motion, hybrid force/ motion Control.	

Learning Resources	1. *M.W.Spong, S.Hutchinson and M. Vidyasagar, Robot Modelling and Control, John Wiley & Sons Inc.,2006.* 2. *Abhinandan Jain, Robot and Multibody dynamics – Analysis and Algorithms, Springer, 2011* 3. *Edward Y.L. Gu , A Journey from Robot to Digital Human, Springer, 2013*	4. *B. Siciliano, O. Khatib (Eds), Springer Handbook of Robotics, Springer, 2008.* 5. *S.V.Shah, S.K. Saha and J. K. Dutt, Dynamics of Tree-Type Robotic Systems, Springer, 2018.* 6. *B.Siciliano, L. Sciavicco, L. Villani, G.Oriolo, Robotics- Modelling, Planning and Control, Springer, 2009.* 7. *Edward Y.L. Gu ,"Advanced Dynamics Modeling, Duality and Control of Robotic Systems", CRC press, 2021.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.K.Vibha, SRM IST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

ACADEMIC CURRICULA

Automation and Robotics & Electronics and Control Engineering

Common Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIE501T	Course Name	ADVANCED POWER ELECTRONICS AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the operation of advanced power semiconductor device and AC-DC Converter*
CLR-2:	*explore the concept of multi-level DC-AC Inverter*
CLR-3:	*know the process of Advanced Electrical drives for various application*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the advanced power semiconductor devices and Advanced AC-DC Converter*	3		
CO-2:	*analyze the operation, switching techniques and basics topologies for multi-level Inverter*	3		
CO-3:	*analyse the process of Advanced Electrical drives for various application*			3

Module-1 AC-DC Converter	***18 Hour***
Review of power semiconductor devices, Thyristor, IGBT, MOSFET, IGCT, GTO and their driver circuits- Role of SiC in power semiconductor technology- Uncontrolled rectifier, semi-controlled rectifiers, fully controlled rectifiers with R, RL and RLE load- Effect of source inductance on performance of converter, firing schemes and circuits- Multi-pulse converters, 12,18 and 24 pulse converters, phase shifting transformers- Power factor improvement techniques, PWM rectifiers, sine PWM, single phase and three phase boost rectifier circuits.	
Module-2 Multi-level Inverter	***15 Hour***
Voltage Source Inverter- 120º and 180º conduction modes - Selective Harmonic Elimination (SHE), sine modulation- Third harmonic injection, hysteresis current Control, Sigma-Delta modulation, space vector pulse width modulation- Under modulation, overmodulation and their implementation- Current Source Inverter- Role in high power drives- Auto sequential current fed inverter, Pulse width Modulation of CSI Matrix converters- Three phase matrix converters and their control, basic input filter, protection of matrix converter- Multilevel inverters- Diode clamped MLI, Flying Capacitor MLI, Cascaded H-Bridge topology, operation with equal and unequal DC voltages- Carrier modulation schemes of multilevel inverter, SVPWM of Multilevel inverter- Neutral point balancing schemes.	
Module-3 Advanced Electrical Drives	***12 Hour***
Feedback control for converters- Regulation and control problem, control principles, model for feedback- P and PI control- Nonlinear dynamic modeling, Control and analysis of choppers, voltage mode and current mode control- Simulation- process, mechanics, techniques, PSPICE simulator- EMI and Power Quality Problems- Power conditioning- PLL, Microcomputer based converters and choppers- Power electronic converters for microgrid applications.	

Learning Resources		
	1. *G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, "Thyristorised Power controllers", New Age International Publishers, First Edition, Reprint 2005.*	4. *Yang Han, "Modeling and Control of Power Electronic Converters for Microgrid Applications", springer, 2022*
	2. *Ned Mohan, Tore M. Undeland and William P. Robb and, John Wiley and Sons, Third Edition, 2002, "Power Electronics Converter and Applications design".*	5. *Bacha, Seddik, Munteanu, Iulian, Bratcu, Antoneta Iuliana, "Power Electronic Converters Modeling and Control", Springer, 2014.*
	3. *Fang Lin Luo, Hong Ye, "Power Electronics Advanced Conversion Technologies", Second Edition, CRC press, 2018.*	6. *Vinod Kumar, Ranjan Kumar Behera, Dheeraj Joshi, Ramesh Bansal, "Power Electronics, Drives, and Advanced Applications", CRC press 2020*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.K.Vibha, SRM IST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE506T	Course Name	MODEL BASED DEVELOPMENT OF CYBER - PHYSICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic concepts of cyber-physical system and modeling of a continuous and discrete system*
CLR-2:	*impart the adequate information about hybrid system and state machines*
CLR-3:	*impart the knowledge about verification and validation of embedded system design*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*infer the basic concepts of CPS and modeling in continuous and discrete domain*	3		2
CO-2:	*formulate the hybrid system and its interactions*	3		2
CO-3:	*design, develop and validate the embedded system design for specific applications*	3		2

Module-1 - Introduction to Continuous and Discrete Dynamics Modeling	***15 Hour***
Structure of Cyber-Physical Systems - Design Process - Modeling – Design – Analysis - Actor Models - Properties of Systems, Causal Systems, Memoryless systems - Linear-Time Invariant – Stability -Feedback Control - Transformation to Equivalent Model, Physical Dynamics, Modeling and Simulation Tools - Problems – BIBO Stability analysis - Discrete Systems - Event Triggered - Modeling Actors as Function - Finite-State Machines, Transitions, Reaction - Update Functions - Traffic light controller.	
Module-2 - Hybrid Systems and State Machines	***15 Hour***
Modal Models – Combining Discrete and Continuous Dynamics - Actor Model for State Machines - Actor representation of FSM - Thermostat example - State Refinements, Notations of Hybrid Systems, Classes of Hybrid systems -Timed Automata - Timed automation variant of traffic light controller - Hybrid system model for mass system - Automated guided vehicle, Composition of state machines, Concurrent composition - Side-by-Side Synchronous Composition - Side-by-Side Asynchronous Composition - Shared Variables - Cascade Composition - Hierarchical State Machines	
Module-3 - Design, Analysis and Verification of Embedded Systems	***15 Hour***
Embedded Processors - Parallelism vs concurrency - Instruction level parallelism, Memory Technologies, Memory Hierarchy - Memory maps - I/O Hardware - Sequential Software, A/D Interface, Multitasking - Basics of Scheduling – Invariants - Traffic light controller example - Safety, Liveness Properties, Models as Specifications - Abstraction and Refinement - Garage counter example, Finite sequences, Simulation Relations - Non-Uniqueness of Simulation - Bisimulation	

Learning Resources		
	1. *E.A.Lee, S.A.Sashia, Introduction to Embedded Sytems : A Cyber-Physical Systems Appproach, MIT Press, 2nd edition.,2017.*	3. *Nonita Sharma, L K Awasthi, Monika Mangla, K P Sharma, Rohit Kumar, Cyber-Physical Systems: A Comprehensive Guide, CRC Press, 2022.*
	2. *Walid M. Taha , Abd-Elhamid M. Taha , Johan Thunberg, Cyber-Physical Systems: A Model-Based Approach, Springer, 2021.*	4. *Anupam Baliyan, Kuldeep Singh Kaswan, Naresh Kumar, Kamal Upreti, Ramani Kannan, Cyber Physical Systems Concepts and Applications, CRC Press, 2023.*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in	1. Dr. G.Y.Rajaa Vikhram, SRMIST
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE508T	Course Name	VFD AND HMI PROGRAMMING	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	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide knowledge on the basics of inverter and its operation modes*
CLR-2:	*know the interfacing and configuration parameters for VFD*
CLR-3:	*provide knowledge on HMI Programming*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*use different modes of operations for VFD*	1		2
CO-2:	*select appropriate interfacing module and parameter settings*	2		
CO-3:	*develop a user interface for a particular sequence using HMI*	2		2

Module-1 – Variable Frequency Drive Operations	***15 Hour***
Basics of inverter -Inverter selection - Selection of peripheral devices - Motor types - Power and signal connections–Parameters - Different types of load patterns - Different modes of operations - PU, external& net mode, JOG operation - I/O assignment - Calibration function - PTC interface - Pulse Input, V/F control – SVC - Vector Control - PM Control - Auto tuning (offline, online), speed, torque, position control - Dynamic braking - Regenerative - braking - VFD Operational Faults and operational key based troubleshooting	
Module-2 - Interfacing	***12 Hour***
I/O option interface - Closed loop interface - Optional network interfaces- RS485, MODBUS, field bus, Ethernet, SSCNET - Inverter control using PLC - Direct communication interface with MODBUS, CC-Link, IE Communication - Troubleshooting -error massage, warning, alarm, major faults, reset function - Advance features - PID function -Brake sequence function	
Module-3 – Human Machine Interface	***18 Hour***
HMI monitor and enclosure - alarms, event history, trend, graphics library - New Project Creation - Configuration of GOT communication with PLC - OS Selection and Installation: Boot OS - Standard Monitor OS - Communication Driver - Different types of Screens - Screen Design using Various Objects like Switch/Lamps/Text and Numerical Display - Part Display and Part Routes - Comments/ Comment Groups/ Comment Display -User Alarms: Alarm configuration and Alarm Display - Objects from Library - Recipe function - Script: Project and Screen Scripts - Screen Security and Project Security configuration - Logging Functions and Time Action - Document display - Network Monitoring -Intelligent module Monitoring - Ladder Monitoring and Editor- Case study: VFD used in Closed loop for Controlling Mechanical rotatory equipment such as Oxidation Blower, Compressor, Pump and Vibrating Feeders	

Learning Resources	
1. *Malekar, A., Malekar, A., Learn Everything about Factory Automation: Practical Lessons on PLC, HMI, VFD, Servo Programming and Machine Automation, 2021*	3. *F. Gardner, R., F. Gardner, R., Introduction to Plant Automation and Controls. United States: CRC Press, 2020*
2. *Gurocak, H., Gurocak, H., Industrial Motion Control: Motor Selection, Drives, Controller Tuning, Applications. Germany: Wiley, 2016*	4. *Samuel Guccione, James McKirahan, Human Machine Interface, Concepts and Projects, Industrial Press, 2016*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. N. Natarajan, M.Eng,, ETAS GmbH	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. J. Sam Jeba Kumar, SRMIST*
2. Himanshu Shekhar ,L&T Energy	*2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE602T	Course Name	EMBEDDED CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

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

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the significance of embedded controllers in Embedded Systems design*
CLR-2:	*impart knowledge on human Machine Interfaces and their design constraints*
CLR-3:	*introduce the significance of PetriNets and Statecharts in Embedded System Modeling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the significance of embedded controllers in Embedded Systems design*	-	2	-
CO-2:	*analyze the importance of HMI in an embedded control system*	-	-	3
CO-3:	*apply the knowledge of PetriNets and Statecharts in Embedded System Modeling*	3	-	3

Module-1 - Embedded Controller Design	***15 Hour***
Introduction to Embedded systems - Overview of cyber-physical systems - Real Time Embedded Control System - Real time scheduling - I/O Management - Embedded Operating Systems- Networking Protocols - Systems on chip - Memory Subsystem - Bus Structure - Interfacing Protocol - Peripheral Interfacing - Power Management - Embedded System Software Programming Optimization - Concurrent Programming	
Module-2 - Dynamics and Debugging	***15 Hour***
Continuous dynamics- Discrete dynamics - State machines - Security - Reliability testing - Heuristic evaluation- Interface requirements - Implementation challenges - Processes and real time operating systems - High level simulation - Low level simulation – Onboard debugging - Task level debugging - Emulation - Examples of system design	
Module-3 – Embedded System Modeling	***15 Hour***
State charts - Modeling Hierarchy - Specification Description Language (SDL) - Petri Nets - Embedded systems modeling with Petri Nets - Unified Modeling Language (UML) - Activity diagram - Class diagram - Component diagram - Use-case diagram - Sequence diagram - UML specification examples - Peripheral Interfaces used in Embedded Systems	

Learning Resources		
	1. *Steve heath, Embedded System Design, 3rd Edition, Packt Publishing, 2013* 2. *Josheph Yiu, The definitive Guide to ARM Cortex M3 and M4 Processors, 3rd Edition, Elsevier, 2013* 3. *Shanthanu Chattopadhyay, Embedded System Design, 1stEdition, PHI learning, 2013*	4. *Prof. Santanu Chaudhary, Introduction to Embedded Computing, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, https://nptel.ac.in/courses/108102045* 5. *Lawrence J. Henschen, Julia C. Lee, "Embedded System Design Methodologies and Issues", Elsevier Science, 2023*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Vikranth, Asst Manager (R&D), TICMPL	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. R.Bakiya lakshmi, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE604T	Course Name	DEEP LEARNING TECHNIQUE	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	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of Machine Learning and Deep Learning*
CLR-2:	*analyze Various Deep Learning Architectures*
CLR-3:	*analyze the deep learning methods for speech, Image, and Biomedical signal processing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply appropriate deep learning algorithms to analyze datasets and make accurate predictions.*	3		
CO-2:	*ability to design and implement advanced neural networks and deep learning networks for solving tasks.*	3		2
CO-3:	*evaluate the performance of deep learning models using appropriate metrics and optimizing them for better results with Speech, Image and Bio-medical Signals.*	2	2	2

Module-1 - Fundamentals of ML and DL	***12 Hour***
Basics of Machine Learning (ML), Supervised Learning, Unsupervised Learning, Stacked, Sparse, Denoising Autoencoders and Ladder Training, Cost functions, Learning Rate Dynamics and Optimization, Reinforcement Learning, Introduction to Deep Learning, Perceptron Algorithm, Multilayer Perceptron (Neural Networks), ML vs Deep Neural Networks.	
Module-2 – Deep Learning Algorithms	***13 Hour***
Basic Building Blocks of CNN, Forward and Back propagation in CNN, Classic CNN Architectures, Modern CNN Architectures, Basic Building Blocks of RNNs, RNNs and Properties, Deep RNN Architectures.	
Module-3 – DL in Speech, Image and Bio-Medical Signal Processing Applications	***20 Hour***
A case study approach on Real time Analysis of speech, image and Bio-medical signal Processing - Pre-processing, Feature extraction and Implementation of Classification based on Deep learning methods.	

Learning Resources	
1. *Uday Kamath • John Liu • James Whitaker, Deep Learning for NLP and Speech Recognition, Springer nature, 2019.*	4. *"Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli,*
2. *Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020.*	5. *Springer, 2007.Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017*
3. *Deep Learning, Ian Goodfellow, Yoshua Bengio & Aaron Courville, MIT Press, 2016.*	6. *Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress,2017*

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

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. A.Brindha, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE605T	Course Name	VIRTUAL AND AUGMENTED REALITY	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	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart the implications of a virtual environment*
CLR-2:	*know the significance of GUI in virtual environment*
CLR-3:	*provide knowledge on the design requirements for 3D manipulation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the benefits and implications of a virtual environment*	-	2	-
CO-2:	*apply various controls for GUI design in virtual environment*	3	-	3
CO-3:	*analyze the design requirements for 3D manipulation*	-	-	3

Module-1 - Immersive Technologies	***15 Hour***
Virtual Reality and Virtual Environment-The historical development of VR –Scientific landmarks Computer Graphics- Real-time Computer Graphics- Virtual environments- Requirements of VR-Visual displays- Auditory displays- Haptic displays- Choosing Output devices for 3D User Interfaces- Input device characteristics- Desktop input devices- Tracking devices- 3D Mice- Special Purpose Input Devices- Direct Human Input- Home-Brewed Input Devices- Choosing Input devices for 3D interfaces	
Module-2 – Graphical User Interface Design	***15 Hour***
Database –World Space- World coordinate- World environment- Objects –Geometry- Position / Orientation- Hierarchy- Bounding Volume- Scripts and other attributes- VR Environment –VR Database- Tessellated Data-LODs- Cullers and Occluders- Lights and Cameras- Scripts- Interaction –Simple- Feedback- Graphical User Interface- Control Panel- 2D Controls- Hardware Controls- Room / Stage / Area Descriptions- World Authoring and Playback- VR toolkits	
Module-3 - 3D Module Design	***15 Hour***
3D Manipulation tasks- Manipulation techniques and Input devices- Interaction Techniques for 3D Manipulation- Design Guidelines –3D Travel tasks- Travel Techniques- Design Guidelines –Theoretical Foundations of Wayfinding- User Centered Wayfinding Support- Environment Centered Wayfinding Support- Evaluating Wayfinding Aids- Design Guidelines –System Control- Classification- Graphical Menus- Voice commands- Gestural Commands- Tools- Multimodal System Control Techniques- Design Guidelines	

Learning Resources	1. *Dieter Schmalstieg and Tobias Hollerer, Augmented Reality: Principles and Practice (Usability), Pearson Education (US), 1st Edition, Addison-Wesley Educational Publishers Inc, 2016.* 2. *C. Burdea and Philippe Coiffet, Virtual Reality Technology, 2nd Edition, Gregory, John Wiley and Sons Inc.,2008*	3. *Steve Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability), 1st Edition, Addison-Wesley Professional; 2016* 4. *Jason Jerald, The VR Book: Human-Centered Design for Virtual Reality. Association for Computing Machinery, 1st Edition, Morgan & Claypool, 2015* 5. *Manivannan, Course on Virtual Reality Engineering, Department of CSE, IIT Madras, https://nptel.ac.in/courses/121106013*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
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Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
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Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Jai Nareesh, Manager AR/VR Programs, HP	*1. Dr. P. Karthikeyan, MIT Campus, Anna University*	1. *Dr. R.Bakiya lakshmi, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

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

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