Robotics & Artificial Intelligence
VI SEMESTER

Embedded system design (PCC)

Course Code	**22RI 61**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- The course will enable the students to
- Understand basic embedded system concepts, architectures, and hardware components.
- Learn microcontroller programming and peripheral interfacing.
- Understand real-time system principles and RTOS fundamentals.
- Gain knowledge of embedded communication and system integration for robotics.
- Develop skills to design and implement an embedded system project using sensors, actuators, and AI modules.

Course Outcomes: At the end of the course student will be able to

CO1: Understand basic embedded system concepts, architectures, and hardware components.

CO2: Develop microcontroller programs using GPIO, timers, PWM, ADC/DAC, serial interfaces, &interrupts.

CO3: Apply real-time system concepts and Free-RTOS for multitasking and synchronization.

CO4: Implement communication protocols and integrate embedded systems with robotic subsystems.

CO5: Design and demonstrate an embedded project using sensors, actuators, and AI inference modules.

Module-1

Fundamentals of Embedded Systems: Definition and characteristics of embedded systems, Von Neumann and Harvard architectures, Microcontroller vs. Microprocessor, Basic hardware components (CPU, memory, peripherals), Digital I/O concepts, Sensors and actuators overview, Introduction to development boards (Arduino/Pico), Embedded workflow, Simple programs using GPIO.	CO1

Module-2

Microcontrollers and Peripheral Interfaces: ARM Cortex-M architecture overview, GPIO configuration, Timers and PWM generation, ADC and DAC operations, Serial communication interfaces (UART, SPI, I²C), Interrupts and exception handling, Register-level programming basics, Reading datasheets and reference manuals, Interfacing sensors and motor drivers.	CO2

Module-3

Real-Time Systems and RTOS Concepts: Real-time requirements (latency, jitter), Hard and soft real-time constraints, Task scheduling algorithms, Multitasking and context switching, Memory management in embedded systems, Synchronization tools (queues, semaphores, mutexes), Introduction to Free-RTOS, Creating and managing tasks, Inter-task communication.	CO3

Module-4	
Module 4: Embedded Communication and System Integration Communication protocols for robotics (CAN, RS485, SPI, I²C, UART), Wireless modules (WiFi, BLE), Sensor fusion interfaces (IMU, encoders, GPS), Data acquisition and buffering, Debugging tools (JTAG, SWD, logic analyzer), Embedded-to-ROS communication basics, Integration of microcontrollers with robotic subsystems.	CO4

Module-5	
Embedded system design project: Hands-on project designing a basic embedded system integrating sensors, actuators, and AI inference modules. Emphasis on system-level design, power management, and debugging for robotic applications, culminating in a functional prototype demonstration.	CO 5

Suggested Learning Resources

Books

1. **Kamal, R.** (2015). *Embedded Systems: Architecture, Programming and Design*. McGraw Hill Education, India.
2. **Valvano, J. W.** (2018). *Embedded Systems: Introduction to ARM Cortex-M Microcontrollers*. Pearson Education / ARM University Program.
3. **White, E.** (2011). *Making Embedded Systems: Design Patterns for Great Software*. O'Reilly Media.

Reference Books

1. **Li, Q. & Yao, C.** (2003). *Real-Time Concepts for Embedded Systems*. CMP Books.
2. **Barr, M. & Massa, A.** (2006). *Programming Embedded Systems with C and GNU Development Tools*. O'Reilly Media.
3. **Simon, D.** (2010). *An Embedded Software Primer*. Addison-Wesley Professional.

E-Books / MOOCs / NPTEL

1. **Embedded Systems** – Prof. Anshul Kumar, IIT Delhi (NPTEL)
2. **Real-Time Systems** – Prof. Rajib Mall, IIT Kharagpur (NPTEL)
3. **ARM Based Embedded Systems** – IIT Madras (NPTEL)

CO-PO Map:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	–	3	3	–	2	2	–	–
CO2	3	3	1	1	2	1	1	–	3	3	–	2	2	1	–
CO3	3	3	2	1	2	1	1	1	3	3	–	2	3	2	1
CO4	3	3	3	3	3	1	1	1	3	3	–	3	1	1	1
CO5	3	3	3	3	3	1	1	1	3	3	–	3	1	1	1

3 – Strong, 2 Moderate, 1-Weak

Robot Operating System(IPCC)

Course Code	**22RI62**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-2	SEE Marks	50
Total Hours of Pedagogy	52	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

The course aims to:

- Introduce the architecture and basic concepts of the Robot Operating System (ROS).
- Enable students to develop and deploy modular robot software using nodes, topics, services, and actions.
- Provide hands-on experience with robot simulation tools such as RViz and Gazebo.
- Familiarize students with robot perception, navigation, and control using ROS packages.

Course Outcomes: At the end of the course students will be able to

CO1: Explain about the basics of ROS and its architecture.

CO2: List the existing ROS commands for interfacing and establish communication with the robot.

CO3: Design and simulate the robot in robot simulation software.

CO4: Design and develop hardware software interfacing kernel to modify ROS.

Module-1		
Introduction to ROS: Introduction –The ROS Equation - History - distributions -difference from other meta-operating systems– services - ROS framework – operating system – releases. Installation of ROS on Ubuntu		CO1
Lab Exercises	1. Experiment on creating, building, modifying packages, and writing, building source code and nodes. 2. Setting up the ROS Environment.	
Module-2		
ROS Computation Graph: UNIX commands - file system – redirection of input and output - File system security - Changing access rights– process commands – compiling, building and running commands – handling variables		CO2
Lab Exercises	1. Creating and Running Service Servers and Client Nodes. 2. Writing and Running the Action Server and Client Node.	
Module-3		
Perception, Control and Navigation: File system - packages – stacks – messages – services – catkin workspace – working with catkin workspace – working with ROS navigation and listing commands. Navigation through file system -Understanding of Nodes – topics – services – messages – bags – master – parameter server		CO3
Lab Exercises	3. Programming experiment on nodes with setting, reading, building, running, displaying parameter list. 4. Turtlesim Control Using ROS Topics.	

Module-4		
Robot Modeling and Simulation: Debugging of Nodes – topics – services – messages – bags – master – parameter – visualization using Gazebo– RViz – URDF(Unified Robot Description Format) modeling – Xacro – launch files		CO4
Lab Exercises	3. Experiment on 3D visualization tool (RViz). 4. Design and development of a graphical user interface in the ROS environment.	
Module-5		
Hardware Interface: Sensor Interfacing – Interfacing sensor data (LIDAR, camera, IMU) in ROS. Sensor Drivers for ROS – Actuator Interfacing – Motor Drivers for ROS. Debugging, data logging (rosbag), visualization, and testing.		CO5
Lab Exercises	3. Sensor Integration and Data Handling. 4. Autonomous Task Integration	

Suggested Learning Resources:

Books

1. Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018. Aaron Martinez,
2. Enrique Fernández, "Learning ROS for Robotics Programming", Packt Publishing Ltd, 2013.

Reference Books

1. Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
2. Anis Koubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
3. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017

E Books / MOOCs/ NPTEL

4. http://wiki.ros.org/ROS/Tutorials
5. https://docs.ros.org/en/foxy/index.html
6. https://www.youtube.com/c/RoboticsBackEnd

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	-	-	1	3	-	-	-	1	1	-	1	2	2	2
CO 2	3	-	-	1	3	-	-	-	1	1	-	1	2	2	2
CO 3	3	3	3	2	3	-	-	-	1	1	-	1	2	2	2
CO 4	3	3	3	3	3	-	-	-	1	1	-	1	2	2	2

3 – Strong, 2 Moderate, 1-Weak

IMAGE PROCESSING AND ITS APPLICATION (IPCC)			
Course Code	**22RI63**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-2	SEE Marks	50
Total Hours of Pedagogy	52	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- To understand the basics of image processing
- To examine the working of filters and morphological operations
- To examine the working of neural networks
- To analyze various deep learning algorithms
- To analyze YOLO algorithm and other neural networks

Course Outcomes: At the end of the course student will be able to

CO1: Understand the basics of image processing

CO2: Use different filters and to perform morphological operations

CO3: Apply neural networks for various operations using open CV

CO4: Analyse various deep learning algorithms

CO5: Analyse YOLO algorithm and other neural networks

Module-1	
Introduction to Image Processing: Introduction to Image Processing, Fundamental steps in image processing, Components of Image Processing system, Image sensing and acquisition, Image sampling and quantization, Application of Image processing, Color Models	CO1

Module-2	
Image Processing Techniques: Basic Grey level transforms, Histogram processing, histogram equalization, Smoothing frequency domain filters, Sharpening frequency domain filters, Image degradation/restoration process, noise models, Mean filter, Median filter, Mid-point filter, Image segmentation, Morphological operations	CO2

Module-3	
Introduction to open CV and neural networks: Image processing using open CV, Shape detection using open CV, Fundamentals of Deep learning, Layers in neural network, neurons, hyperparameters, bias, activation function, sigmoid function, tanh function, ReLU, Softmax function, learning rate, backpropagation, overfitting, gradient descent, loss function, deep learning libraries, Tensor, convolution, Pooling layer, fully connected layer	CO3

Module-4	
Introduction to object detection: LeNet – 1, LeNet – 4, Boosted LeNet – 4, LeNet – 5 architecture, AlexNet neural network, VGG Neural network – VGG 16, Object detection and use cases, Object detection methods, Deep learning frameworks for object detection, R- CNN architectures	CO4
Module-5	
Introduction to deep learning algorithms: Features and Loss function in YOLO algorithm, YOLO architecture, Single shot multibox detector – SSD, Transfer learning, FaceNet for face recognition, ResNet architecture, Inception network, GoogLeNet architecture, Video processing	CO5

COURSE CONTENTS (PRACTICAL)

#	NAME OF THE EXPERIMENT	CO
1	Write a program to perform basic image processing operations	1
2	Write a program to generate the histogram of an image and filter the image	2
3	Write a program to perform image segmentation and morphological operations	2
4	Write a program to detect color using open CV	3
5	Write a program to detect shapes using open CV	3
6	Write a program to detect face using open CV	3
7	Write a program to distinguish between cat and dog based on their image	3
8	Write a program to classify models using LeNet	4
9	Write a program to identify traffic signs using LeNet	4
10	Write a program to implement FaceNet for face recognition	5
11	Write a program to recognize gestures using python	5
12	Write a program to detect multiple objects in an image	5

Suggested Learning Resources:

Books

1. Divya BS, Nanjundaswamy HR, “Image processing” (Module 1 and 2)
2. Vaibhav Verdhan “Computer vision using deep learning” apress publication (Module 3,4,5)
3. Digital Image Processing by Rafael C. Gonzalez

Reference Books

6. Fundamentals of Digital Image Processing by Anil K. Jain
7. Image Processing and Acquisition using Python by Ravishankar Chityala
8. Introduction to Digital Image Processing by William K. Pratt

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2		3				3	2		2		3	
CO 2	3	3	3		3				3	2		2		3	
CO 3	3	3	3		3				3	2		2		3	
CO 4	3	3	3		3				3	2		2		3	
CO 5	3	3	3		3				3	2		2		3	

3 – Strong, 2 Moderate, 1-Weak

Professional Elective Course-II			
MEDICAL ROBOTICS (PEC)			
Course Code	**22RI641**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To impart basic understanding of robotics.
- To comprehend on the application of robotics in the field of healthcare
- To enable understanding the design and control concepts of medical robots

Course Outcomes: At the end of the course student will be able to

CO1:Identify the paradigms of Surgical Robots, basic parameters joints, DOF.

CO2:To understand the skills and implement robotic assistant for both Minimally Invasive Surgery and Image-Guided Interventions.

CO3:To know the parameters of knowledge of rehabilitations of exoskeleton systems.

CO4:To understand applications of robotics in critical surgery.

CO5:To understand the robot design concepts and current trending concepts of medical robots and its cutting edge fields.

Module-1	
Introduction to Medical Robots: Introduction to Bio-medical robots, Types of Medical Robots, Navigation and paradigms of Bio-Medical Robots, Forward kinematics, Inverse, Spatial transformations, Joints, Links, Degrees of freedom of biological systems, Benefits of Robots in Health Care Industries.	CO1
Module-2	
Minimally Invasive Surgery: Introduction to Minimally Invasive Surgery, Video Images in MIS, Teleoperation, Augmented and Virtual Reality. **Image-Guided Interventions:** Medical Imaging Modalities: CT, US, MRI, Needling systems Passive and active needles,-Unicyle, Bicycle Modeling, actuators-smart actuator such as Shape Memory Alloys, Image Guided feedback control system.	CO2
Module-3	
Rehabilitation of Robotics: Introduction, Exoskeletons-Design concepts, Development and control- Human hand-Biomechanics, Rehabilitation for Limbs-Brain-Machine-Interfaces, Redundancy resolution, Only introduction to Rehabilitation Strategies, Steerable needles.	CO3
Module-4	
Bio-Medical robots for Surgical applications: Introduction to Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric-, and General- Surgery, Gynecologic Surgery and Nano robotics.	CO4

Module-5	
Design of Medical Robots: Characterization of gestures to the design of robot- design methodology- technological choices- security. **Current Topics in Bio-Medical Robotics:** Haptic Augmentation in Exoskeletons, Robotic Catheters for percutaneous interventions, Unsupervised learning for mapping in Bio-Robots, Reven–II Robots. Future Trends of Robotics In the Medical Field.	CO5

Text Books:

1. Mark W. Spong, Seth Hutchinson, and M. Vidyasagar, “Robot Modeling and Control”, Wiley Publishers, 2006.
2. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012
3. Nagrath and Mittal, “Robotics and Control”, Tata McGraw-Hill, First edition, 2003.
4. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008

Reference Books:

1. AchimSchweikard, Floris Ernst, “Medical Robotics”, Springer, 2015.
2. Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012.
3. VanjaBonzovic, ”Medical Robotics”, I-tech Education publishing,Austria,2008.
4. Current trend of robotics application in medical, OA Olanrewaju1, AA Faieza 2 & K Syakirah3, IOP Conf.Series: Materials Science and Engineering 46 (2013) 012041doi:10.1088/1757-899X/46/1/012041.
5. https://waykenrm.com/blogs/medical-robots/

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	1	2	3
CO 2	3	2	1	-	-	-	-	-	-	-	-	-	1	1	3
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	1	2	3
CO 4	3	2	1	-	-	-	-	-	-	-	-	-	1	2	3
CO 5	3	2	2	-	-	-	-	-	-	-	-	-	2	-	3

3 – Strong, 2 Moderate, 1-Weak

FUNDAMENTALS OF AUGMENTED AND VIRTUAL REALITY (PEC)			
Course Code	**22RI642**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To describe the basics of AR and VR
- To explore the hardware and software
- To design and develop skills towards 3D game and animation.

Course Outcomes: At the end of the course student will be able to

CO1: Describe how AR systems work and list the applications of AR

CO2: Analyse the hardware requirement of AR.

CO3: Explain the concepts of motion and tracking in VR systems.

CO4: To understand the Geometry of the virtual word and also to interpret the human physiology.

CO5: Describe the motion and tracking systems.

Module-1	
Introduction to Augmented Reality: Defining augmented reality, history of augmented reality, The Relationship between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum between Real and Virtual Worlds, applications of augmented reality. Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience. AR Devices & Components: Scene Generator, Tracking system, monitoring system, display, Game Scene Devices. Optical See-through HMD.	CO1
Module-2	
Augmented Reality Hardware: Displays – Audio Displays, Haptic Displays, Visual Displays, and Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. Tracking & Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion.	CO2
Module-3	
Introduction to Virtual Reality: Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality. Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR.	CO3
Module-4	
The Geometry of Virtual Worlds & The Physiology of Human Vision: Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.	CO4
Module-5	
Motion & Tracking : Motion in Real and Virtual Worlds- Velocities and Accelerations, The Vestibular System, Physics in the Virtual World, Mismatched Motion and Vection Tracking-Tracking 2D & 3D Orientation, Tracking Position and Orientation, Tracking Attached	

Bodies.	CO5

Text Books:

1. Schmalstieg, Hollerer, “Augmented Reality: Principles & Practice,” Pearson Education India, 1st Edition, 2016, ISBN-10: 9332578494
2. Steven M. LaValle, “Virtual Reality,” Cambridge University Press, 2016
3. Alan Craig, William Sherman and Jeffrey Will, Developing Virtual Reality Applications, Foundations of Effective Design, Morgan Kaufmann, 2009.

Reference Books:

1. Allan Fowler, “AR Game Development,” A press Publications, 1st Edition, 2018, ISBN 9781484236178

2. William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application amnd Design,” Morgan Kaufmann Publishers, San Francisco, CA, 2002

3. Alan B Craig, William R Sherman and Jeffrey, “Developing Virtual Reality Applications: Foundations of Effective Design,”Morgan Kaufmann, 2009.

Web Link and Video Recourse

 https://www.coursera.org/learn/ar
 https://www.udemy.com/share/101XPi/
 http://lavalle.pl/vr/book.html
 https://nptel.ac.in/courses/106/106/106106138/
 https://www.coursera.org/learn/introduction-virtual-reality.

CO-PO Map:

PO/PSO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	2	-	-	-	-	-	-	-	-	-	1	3	2
CO 2	2	2	1	-	-	-	-	-	-	-	-	-	1	3	2
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	1	3	2
CO 4	2	3	1	-	-	-	-	-	-	-	-	-	1	3	2
CO 5	3	2	2	-	-	-	-	-	-	-	-	-	2	-	2

3 – Strong, 2 Moderate, 1

MECHATRONICS SYSTEM DESIGN (PEC)			
Course Code	**22RI643**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To familiarize about the integration of electronics in mechanical design for automation applications
- To integrate and optimal the design of a mechanical system and its embedded control system.
- To equip students with the skills to design and implement innovative mechatronic solutions for real-world applications.

Course Outcomes: At the end of the course student will be able to

CO1: Gain the knowledge of basics of Mechatronics system design and sensors.

CO2: Understanding various techniques of Mechatronics system design for solving engineering problems.

CO3: Understanding the dynamic responses of systems and Fault detection techniques.

CO4: Determination of optimization solutions, effective decision making, Convert the data in real time interfacing.

CO5: Understand real time mechatronic system design through case study.

Module-1	
Introduction to mechatronics System Design: Mechatronics Definition, integrated design issues in Mechatronics, the Mechatronics design process, the key elements, Application of Mechatronics. Sensors in Mechatronics: sensors for motion and position measurement. Force and pressure sensors. Sensors for temperature measurements.	CO1
Module-2	
Modeling and Simulation of Physical Elements: Operator notation and transfer functions, Block diagrams, manipulations and simulation, block diagram modeling-Direct method and analogy approach, Electrical systems, Mechanical systems(Rotational and Translational), electrical Mechanical Coupling, Fluid systems.	CO2
Module-3	
Dynamic responses of systems and Fault Finding. Modelling of dynamic systems, Terminology, first order systems and second order systems. Fault detection techniques, Parity and error coding checks, Common hardware faults. Microprocessor systems. Emulation and simulation	CO3
Module-4	
Signal Conditioning and Real time Interfacing: Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, and Introduction to digital system processing, pulse-modulation. Introduction, elements of Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for data conversion, Data conversion process, Application software.	CO4
Module-5	
MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing.	

Comprehensive and Data acquisition case studies, data acquisition and control case studies.	CO5

Text Books:

1. Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning
2. Publishing Company, Vikas publishing house, 2001.
3. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999.
4. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
5. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education

Reference Books:

1. Sensor Technology Hand Book – By Jon’s Wilson.
2. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
3. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
4. Mahalik “Mechatronics”- Tata McGraw-Hill Education, 2003
5. HMT “Mechatronics”- Tata McGraw-Hill Education, 1998.

CO-PO Map

3 – Strong, 2 Moderate, 1-Weak

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	3	-	-	-	-	-	-	-	-	-	3	2	3
CO 2	3	2	2	-	-	-	-	-	-	-	-	-	3	2	3
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	3	2	2
CO 4	3	3	3	-	-	-	-	-	-	-	-	-	3	2	3
CO 5	3	2	2	-	-	-	-	-	-	-	-	-	3	-	2

REHABILITATION ENGINEERING (PEC)

Course Code	**22RI644**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To analyze the rehabilitation engineering principles.
- To develop skills of rehabilitation such as Design & Development, Problem Solving, Evaluation & Implementation.
- To innovative technologies, as well as designing customized solutions for diverse needs.

Course Outcomes: At the end of the course student will be able to

CO1: Define rehabilitation and explain the composition of rehabilitation team

CO2: To know tools and assistive devices.

CO3: Design of wheel chair.

CO4: Describe functional electrical stimulation methods

CO5: To know the hearing assistance technologies.

Module-1	
Introduction to Rehabilitation: What is Rehabilitation, Medical Rehabilitation, Preventive Rehabilitation, Impairment, Disability and Handicap, Sociovocational Rehabilitation Rehabilitation Team: Classification of members, Medical, The Rehabilitation team – The medical team, Physical therapist, Occupational therapist, Prosthetist-Orthotist, Rehabilitation nurse, Speech pathologist, Psychologist and child development Specialist, Horticultural Therapist, Music therapist, Creative Movement Therapist, Dance and play Therapist, Recreational therapist, Biomedical engineer.	CO1
Module-2	
Introduction to tools and assistive devices: Tools in clinical practice, universal design, principles and benefits of universal design, examples, assistive technology, Seating biomechanics and systems, design aspects seating systems	CO2
Module-3	
Wheel chair design: manual wheelchairs, basic structural components, electric power wheelchairs, power & drive systems, control system, power-assisted wheelchairs, multifunctional wheelchair intelligent mobility aids, smart wheeled walkers, sensors, software, robotic manipulations aids, therapeutic robots	CO3
Module-4	
Functional electrical stimulation (FES): clinical considerations of FES, electrodes, clinical applications, foot drop and wrist drop, upper extreme function, spinal cord stimulation, deep brain stimulation, gait, upper limb and low limb movements, upper limb and lower limb prosthesis, biomechanical principles of orthotic devices	CO4
Module-5	
Hearing assistance technologies: Types of hearing impairment, Hearing assistance technology solutions, medical or surgical approaches to restoring function, assistive listening solutions,	CO5

Visual substitutions to auditory activities, vocational, daily living, and communication aids	

Text Books:

1. Rehabilitation Medicine – By Dr. S. Sunder, 3rd Edition, Jaypee Medical Publications, Reprint 2004.
2. Rory A Cooper, Hisaichi Ohnabe, Douglas Hobson, "An Introduction to Rehabilitation Engineering", Francis & Taylor/CRC Press, First edition, 2007.

Reference Books:

1. Rehabilitation Engineering Edited by Tan Yen Kheng, Published by In-The, First published December 2009
2. Rehabilitation Engineering Principles and Practice, EDITED BY Alex Mihailidis Roger Smith, CRC Press Taylor & Francis Group.

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	-	-	-	-	-	-	-	-	-	3	2	3
CO 2	3	2	2	3	-	-	-	-	-	-	-	-	3	2	3
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	3	2	3
CO 4	3	3	3	3	-	-	-	-	-	-	-	-	3	2	3
CO 5	3	2	2	-	-	-	-	-	-	-	-	-	3	-	2

3 – Strong, 2 Moderate, 1-Weak

Fundamentals of Robotics and Programming (Open Elective Course-I)			
Course Code	**22RI651**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	45	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Understand and discuss the fundamental elementary concepts of Robotics.
- Provide insight into different types of robots.
- Explain the intelligent module for robotic motion control.
- Educate on various path planning techniques. 4. Illustrate the working of innovative robotic devices

Course Outcomes: At the end of the course students will be able to

CO1: Understand the significance, social impact and future prospects of robotics and automation in various engineering applications.

CO2: Identify and describe the components and anatomy of robotic system.

CO3: Know about various path planning techniques and analyze different motions of the robotics system.

CO4: Use the suitable drives and end-effectors for a given robotics application.

CO5: Apply robotics concept to automate the monotonous and hazardous tasks and categorize various types of robots based on the design and applications in real world scenarios.

Module-1	
Introduction To Robotics: Introduction to Robotics and Automation, laws of robot, brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market and the future prospects, advantages and disadvantages of robots.	CO1

Module-2	
Robot Anatomy And Motion Analysis: Anatomy of a Robot, Robot configurations: polar, cylindrical, Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements, vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix**.**	CO2

Module-3	
Robot Drives And End Effectors: Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, classification of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive gripper, gripper force analysis and gripper design, 1 DoF, 2 DoF, multiple degrees of freedom robot hand, tools as end effectors, Robot control types: limited sequence control, point-to-point control, playback with continuous path control, and intelligent control.	CO3

Module-4	
Path Planning: Definition-Joint space technique, Use of P-degree polynomial-Cubic, polynomial-Cartesian space technique, parametric descriptions, straight line and circular paths, position and orientation planning.	CO4
Module-5	
Robotics Applications: Material Handling: pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, Ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots: Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Robots, Autonomous robots, and Swarm robots	CO5

Suggested Learning Resources:

Books

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education, 2009.
2. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, Special Edition, (2012).
3. Ganesh S Hegde, “A textbook on Industrial Robotics”, University science press, 3rdedition, 2017.

Reference Books

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGraw Hill, 1987. https://www.robots.com/applications.

E Books / MOOCs/ NPTEL

5. https://www.ieee-ras.org/educational-resources-outreach/educational-material-in-robotics-and-automation

CO-PO Map:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	–	3	3	–	2	2	–	–
CO2	3	3	1	1	2	1	1	–	3	3	–	2	2	1	–
CO3	3	3	2	1	2	1	1	1	3	3	–	2	3	2	1
CO4	3	3	3	3	3	1	1	1	3	3	–	3	1	1	1

3 – Strong, 2 Moderate, 1-Weak

Introduction to Mechatronics			
Course Code	**22RI652**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	45	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
- To understand the evolution and development of Mechatronics as a discipline.
- To substantiate the need for interdisciplinary study in technology education
- Understand the applications of microprocessors in various systems and to know the functions of each element.

Course Outcomes: At the end of the course students will be able to

- CO1: Illustrate various components of Mechatronics systems.
- CO2: Assess various control systems used in automation.
- CO3: Develop mechanical, hydraulic, pneumatic and electrical control systems.
- CO4: Design and conduct experiments to evaluate the performance of a Mechatronics system or component with respect to specifications, as well as to analyze and interpret data.

Module-1	
Introduction: Definition of Mechatronics, Multi-disciplinary scenario, Evaluation of Mechatronics, Objectives, Advantages & Disadvantages of Mechatronics, An Overview of Mechatronics, Microprocessor Based Controllers, Principle of Working of Automatic Camera, Automatic Washing Machine & Engine Management System.	CO1
Module-2	
Review Of Sensors and Transducers: Definition and Classification of Transducers, Definition & Classification of Sensors, Working Principle and Application of Displacement, Position & Proximity, Velocity and Motion, Force, Fluid pressure, Liquid flow, Liquid level, Temperature, Light sensors, Selection of transducers.	CO2
Module-3	
Actuators: Introduction and Classification of Actuators: Need and Scope. Pneumatic Actuation system: Single and double-acting actuators. Hydraulic Actuation system: Single and double-acting actuators. Electric Actuation system: Solenoid, relay, stepper motors.	CO3
Module-4	
Microprocessor: Intel 8085, ALU, Timing and Control Unit, Registers, Data and Address Bus, Pin Configuration, Intel 8085 Instructions, Op code and Operands, Timing Diagram. Programming Of Microprocessor: Programming the 8085, Assembly language programming	CO4

Module-5	
Microcontrollers: Introduction to microcontrollers, Intel 8051 Microcontroller Architecture and Pin diagram, Selection and Application of Microcontroller. PLC: Programmable Logic Controllers, Basic Structure, Input/Output Processing, Programming, Mnemonics, Timers, Internal Relays and Counters, Shift Registers, Master and Jump controls, Data handling, Analogue input/output, Selection of a PLC.	CO4

Suggested Learning Resources:

Books

7. Mechatronics - W. Bolton – Pearson Education Asia - 2nd Edition, 2001.
8. Fundamentals of Microprocessor and Micro Computer - B. Ram - Dhanpat Rai and Sons - 4th Revised Edition

Reference Books

9. Mechatronics Principles, Concepts and Application - Nitaigour and Premchand, Mahilik
10. Tata McGraw Hill - 2003. 4. Mechatronics by HMT – TMH

E Books / MOOCs/ NPTEL

6. https://onlinecourses.nptel.ac.in/noc21_me27/preview

CO-PO Map:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	–	3	3	–	2	2	–	–
CO2	3	3	1	1	2	1	1	–	3	3	–	2	2	1	–
CO3	3	3	2	1	2	1	1	1	3	3	–	2	3	2	1
CO4	3	3	3	3	3	1	1	1	3	3	–	3	1	1	1

3 – Strong, 2 Moderate, 1-Weak

Introduction to Digital Twin			
Course Code	**22RI653**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	45	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- Introduce the concept of digital twins and their role in cyber-physical systems and smart technologies.
- Explain the evolution from computational tools to advanced digital twin modeling for dynamic systems.
- Explore various computational and data-driven techniques for building digital twins, including ODE/PDE solvers and frequency/time-domain analysis.
- Discuss open challenges and future directions for digital twin technology across multi-scale and partially known systems.

Course Outcomes: At the end of the course students will be able to

CO1: Explain the fundamentals of digital twin technology and its significance in engineering and science.

CO2: Demonstrate how computational tools evolve into digital twin frameworks for dynamic systems.

CO3: Apply numerical methods for simulating dynamical systems using time-domain and frequency-domain techniques.

CO4: Construct data-driven digital twins using Bayesian filtering, Kalman filters, and probabilistic models.

CO5: Analyze challenges in digital twin development and propose appropriate solutions or modeling strategies.

Module	
Module-1	
Computational tools in science and technology, from computational techniques to digital twins. Different tools in digital twin: Physics-based digital twin in dynamical systems - solution of ODEs and PDEs, Time-domain simulation of dynamical systems.	CO1
Module-2	
Digital twin for dynamical systems - frequency domain analysis. Digital twin for dynamical systems - time domain analysis	CO2
Module-3	
Data-driven digital twins. Bayesian methods in digital twin technology – Kalman filter based approaches.	CO3
Module-4	
Digital twin for multi-timescale dynamical systems - Mixture of Gaussian Process and Expectation maximization. Digital twin from multi-fidelity data. Digital twin for systems with partially known physics.	CO4
Module-5	
Deep learning in digital twin technology - GANS and VAEs. Way forward - challenges and possible ways out.	CO5

Suggested Learning Resources:

Books

1. Iserles, A. (2009). A first course in the numerical analysis of differential equations (No. 44). Cambridge university press.
2. Bishop, C.M. Pattern recognition and Machine learning, Springer, 2007.

Reference Books

1. Murphy, K.P. Machine learning: A Probabilistic Perspective, MIT press, 2012.
2. C. E. Rasmussen & C. K. I. Williams, Gaussian Processes for Machine Learning, MIT Press, 2006 (a free ebook is also available from the Gaussian Processes web site).
3. Additional references will be provided with lecture notes

E Books / MOOCs/ NPTEL

7. https://www.csccm.in/courses/introduction-to-digital-twins

CO-PO Map:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2		2				2	2	–	1	2	2	2
CO2	3	2	2		2				2	2	–	1	2	2	2
CO3	3	2	3	3	2				2	2	–	1	2	2	2
CO4	3	2	3	3	2				2	2	–	1	2	2	2
CO5	3	2	3	3	2				2	2		1	2	2	2

3 – Strong, 2 Moderate, 1-Weak

Introduction to Industrial Automation (PCC)			
Course Code	**22RI654**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	45	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To provide the student with basic skills useful in identifying the concepts of automation using hydraulics, pneumatic and PLC.
- To familiarize with the frame works required in architecture for Industry Automation.
- To introduce edge computing standards and protocols for IoT.
- To introduce Industry 4.0 its applications.

Course Outcomes: At the end of the course students will be able to

CO1: design pneumatic and hydraulic circuits

CO2: program PLC for a given application

CO3: Describe the frameworks required in architecture for Industry automation

CO4: Apply the edge computing standards and protocols for Industrial IoT

CO5: Develop IoT-based automated systems for different applications

Module-1	
Introduction to Automation - Automated manufacturing systems. Sensors and Actuators in Automation - Digital and analog sensors; Fluid power actuators; Control valves; Electrical system elements; Motors drives; Mechanical devices. Pneumatic and Hydraulic Systems - Pneumatic fundamentals - control elements, position and pressure sensing – logic circuits - switching circuits - sequential circuits - cascade method.	CO1
Module-2	
Control Using PLCs - Relay logic; Combinational and sequential control, Sequential flow chart, Minimization of logic equations; Ladder logic diagrams; Programmable logic controllers (PLCs); PLC components; Programming; I/O addresses; Timer and counters; A/D conversion and sampling; PLC applications. Introduction to SCADA Experiments: Logical Circuits - Pneumatic and Electro-Pneumatic Circuits, Study of PLC and PLC-based ElectroPneumatic Sequencing Circuits.	CO2
Module-3	
Protocols for Industrial Automation – ModBus, ProfiBus. Communication Technologies – Wi-Fi, BLE, ZigBee, 6LoWPAN, Fiber Optic Applications: Smart cities & smart homes, connected vehicles, Healthcare, Machine condition monitoring, Process monitoring and control. Experiments: Introduction to Arduino, and ESP8266 (Node MCU)	CO3
Module-3	
Introduction to Raspberry Pi and Installation of OS, Measurement of temperature & pressure values of the process using Raspberry Pi/node MCU, Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/Node MCU, Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry Pi/Node MCU, Demonstration of MQTT communication, Demonstration of LoRa communication	CO4

Module-5	
Industry 4.0 &IoT. Genesis of IoT -IoT and Digitization- IoT Network Architecture and Design-A Simplified IoT Architecture -The Core IoT Functional Stack -IoT Data Management and Compute Stack- Smart Objects - The “Things” in IoT – Sensors – Actuators - Smart Objects - Sensor Networks - Connecting Smart Objects -IoT Devices – End, Edge, and Cloud Systems - IoT Challenges. Introduction to Industry 5.0. Experiments: Familiarizing cloud tools and frameworks. Developing IoT devices (End and Edge nodes for various applications)	CO5

Suggested Learning Resources:

Books

3. Antony Espossito, “Fluid power with Applications ", Pearson, Sixth Edition., 2003.
4. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, First Edition, Cisco Press, 2017.
5. Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Third Edition, Pearson Education, 2009

Reference Books

4. Nanua Singh, Tatla Dar Singh., “Systems Approach to Computer-Integrated Design and Manufacturing”, John Wiley & Sons, 1995.
5. Bahga, Arshdeep, and Vijay Madisetti.Internet of Things: A hands-on approach. Vpt, 2014.
6. Buyya, Rajkumar, and Amir VahidDastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.

E Books / MOOCs/ NPTEL

8. https://onlinecourses.nptel.ac.in/noc21_me67/preview

CO-PO Map:

PO/PSO / CO	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	2		2				2	2	–	1	2	2	2
CO2	3	2	2		2				2	2	–	1	2	2	2
CO3	3	2	3	3	2				2	2	–	1	2	2	2
CO4	3	2	3	3	2				2	2	–	1	2	2	2
CO5	3	2	3	3	2				2	2		1	2	2	2

3 – Strong, 2 Moderate, 1-Weak

Ability Enhancement Course / Skill Enhancement Course-V			
METAL MODEL AND USER EXPERIENCE DESIGN			
Course Code	**22RIL671**	CIE Marks	50
Teaching Hours/Week (L:T:P)	0-0-2	SEE Marks	50
Total Hours of Pedagogy	12	Total Marks	100
Credits	01	Exam Hours	02

Course objectives:

- **To develop foundational skills in metal modeling techniques** such as cutting, bending, joining, and surface finishing for prototyping and product design.
- To introduce the principles and processes of user-centered design**,** including persona development, empathy mapping, and usability evaluation.
- To enable students to design and prototype both physical (metal) and digital (UI/UX) products**,** integrating form, function, and user interaction in the development process.
- To foster iterative design thinking through hands-on experimentation, combining technical fabrication skills with UX research, testing, and evaluation methods.

Course Outcomes: At the end of the course student will be able to

- **Apply fundamental metalworking techniques** such as cutting, bending, joining, and surface finishing to fabricate basic product models or components.
- **Analyze user needs and behaviors** by creating user personas, empathy maps, and conducting basic UX research methods
- **Design and prototype functional physical and digital products** by integrating metal modeling techniques with UX design principles and tools.
- **Demonstrate iterative design thinking** by refining physical and digital prototypes based on usability testing and user feedback

EXPERIMENTS
To understand and perform fundamental sheet metal operations such as cutting, bending, and folding for the fabrication of basic metal components.
To study and apply mechanical joining methods like riveting and screwing in metal parts, and analyze the strength and suitability of each technique.
To learn and apply various surface finishing methods such as grinding, sanding, and polishing to improve the appearance, functionality, and safety of metal prototypes.
To introduce the process of spot welding and allow students to perform spot welds safely on sheet metal, while evaluating joint integrity
To integrate basic metal fabrication skills in the design and construction of a small functional product, following a design-to-prototype workflow
To develop user personas and empathy maps based on user data to better understand user needs, motivations, and pain points in the design process
To quickly visualize and iterate interface ideas through hand-drawn paper prototypes, enabling early-stage usability testing and design refinement.
To conduct structured usability testing on an existing digital product to identify usability issues and gather insights for improving the user experience
To evaluate how users categorize and navigate content by performing card sorting, thereby informing better design of the information architecture
To design mid-fidelity wireframes of a digital interface using UI/UX tools, focusing on layout, navigation, and interaction design
To assess the usability of a digital interface using Nielsen's 10 usability heuristics and recommend improvements based on evaluation findings.

Suggested Learning Resources:

Books

1. **Product Design and Development**, Karl T. Ulrich & Steven D. Eppinger *Publisher:* McGraw-Hill
2. **Manufacturing Processes for Design Professionals** , Rob Thompson, Thames & Hudson
3. **Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products**, David M. Anderson, Productivity Press

Reference Books

1. **The Design of Everyday Things**, Don Norman, Basic Books
2. **About Face: The Essentials of Interaction Design,** Alan Cooper, Robert Reimann, David Cronin, Christopher Noessel, Wiley
3. **Don't Make Me Think: A Common Sense Approach to Web Usability**, Steve Krug, New Riders

CO-PO Map

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2		3							2	3		
2	3	2	2		3							2	3		
3	3	2	2		3							2	3		
4	3	2	2		3							2	3		
5	3	2	2		3							2	3		

DATA MODELING AND VISUALIZATION LABORATORY			
Course Code	**22RIL672**	CIE Marks	50
Teaching Hours/Week (L:T:P)	0-0-2	SEE Marks	50
Total Hours of Pedagogy	12	Total Marks	100
Credits	01	Exam Hours	02

Course objectives:

- To understand the fundamental principles of data modeling and database design using ER models and normalization techniques.
- To develop skills in SQL and Python for querying, cleaning, and transforming data for analysis.
- To explore and apply various data visualization tools and libraries for effective data representation.
- To enable students to build end-to-end data analysis and visualization solutions through practical applications and mini-projects.

Course Outcomes: At the end of the course student will be able to

- Design Entity-Relationship diagrams and apply normalization techniques to build efficient and consistent data models.
- Write SQL queries and use Python libraries to ingest, preprocess, and manipulate structured data for analysis.
- Create basic and advanced visualizations using libraries such as Matplotlib, Seaborn, and Plotly to interpret and communicate data insights.
- Develop a mini project involving data modeling, analysis, and storytelling using real-world datasets and visualization techniques.

EXPERIMENTS
To design an ER model for a real-world scenario (e.g., Library, Hospital, E-Commerce) and convert it to a relational schema.
To apply 1NF, 2NF, 3NF (and optionally BCNF) on a given unnormalized dataset to eliminate redundancy and improve integrity.
To load raw CSV/Excel data into a database or Python environment and perform cleaning operations (e.g., missing value handling, type conversion).
To implement a relational database using SQL based on a given ER diagram, including creation of tables, keys, and constraints.
To write SQL queries for data retrieval, filtering, sorting, and aggregation (GROUP BY, ORDER BY, WHERE, JOIN).
To manipulate tabular data using Pandas (merge, group, pivot, filter) and prepare it for visualization.
To generate bar charts, line charts, and pie charts using Python's Matplotlib library for basic data insights.
To create informative statistical visualizations like boxplots, violin plots, pair plots, and heatmaps using Seaborn.
To build interactive charts using Plotly (line, scatter, bar) and integrate them into a simple web-based dashboard.
To visualize trends in time-series data using line plots, rolling averages, and date/time formatting in Pandas and Matplotlib.
To visualize geographical data using libraries like Folium or Plotly with maps (e.g., plotting earthquake locations, population density).
To conduct a mini-project involving data extraction, modeling, and visualization to tell a compelling story (e.g., COVID trends, sales analysis).

Suggested Learning Resources:

Books

4. **Database System Concepts,Abraham Silberschatz, Henry F. Korth, and S. Sudarshan, McGraw-Hill**
5. **Fundamentals of Database Systems,Ramez Elmasri and Shamkant B. Navathe, Pearson**
6. **Learning SQL, Alan Beaulieu, O'Reilly Media**

Reference Books

4. **Python for Data Analysis, Wes McKinney, Publisher: O'Reilly**
5. Storytelling with Data: A Data Visualization Guide for Business Professionals, Cole Nussbaumer Knaflic, Wiley

CO-PO Map

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2		3							2		3	
2	3	2	2		3							2		3	
3	3	2	2		3							2		3	
4	3	2	2		3							2		3	
5	3	2	2		3							2		3	
Overall mapping	3	2	2		3							2		3	

DRONE LAB			
Course Code	**22RIL673**	CIE Marks	50
Teaching Hours/Week (L:T:P)	0-0-2	SEE Marks	50
Total Hours of Pedagogy	12	Total Marks	100
Credits	01	Exam Hours	02

Course objectives:

- To introduce the fundamental components, assembly, and operation of unmanned aerial vehicles (UAVs) and multirotor drones.
- To develop skills in calibrating, configuring, and manually operating drones using flight controllers and remote control systems
- To enable programming of autonomous drone missions using ground control software and GPS waypoint navigation
- To provide hands-on experience in integrating sensors, capturing aerial data, and performing basic drone-based applications.

Course Outcomes: At the end of the course student will be able to

- Identify and assemble drone components, understanding their roles in UAV structure and flight
- Calibrate sensors and operate drones safely through manual and semi-autonomous control modes
- Program and execute basic autonomous missions using ground control software and GPS navigation
- Integrate basic sensors or cameras with a drone platform and conduct elementary drone applications such as aerial imaging or surveying

EXPERIMENTS
To identify and assemble basic drone components.
To study standard drone operation procedures, safety measures, and local UAV flight regulations.
To calibrate sensors and controllers for stable and safe flight.
To perform a simple takeoff, hover, and landing under manual control using a remote controller.
To learn how to safely charge, discharge, and maintain LiPo batteries used in drones.
To manipulate tabular data using Pandas (merge, group, pivot, filter) and prepare it for visualization.
To flash and configure open-source flight controller firmware.
To program a basic waypoint mission using ground control software like **Mission Planner** or **QGroundControl**.
To connect and configure telemetry modules (e.g., 433 MHz, Wi-Fi) between ground station and drone.
To use GPS modules for position hold, return-to-home, and location-based missions.
To mount a camera and capture real-time images or video using FPV or onboard recording.
To plan and execute a simple aerial mapping or surveillance mission with image capture and GPS tagging.

Suggested Learning Resources:

Books

1. Make: Drones – Teach an Arduino to Fly, David McGriffy, Maker Media
2. DIY Drones for the Evil Genius,Ian Cinnamon, Romi Kadri, and Foreword by Chris Anderson, McGraw-Hill
3. Introduction to UAV Systems, Paul G. Fahlstrom and Thomas J. Gleason, Wiley

Reference Books

1. Programming AR.Drone with Python, Joseph Howse, Packt Publishing
2. Drones (The MIT Press Essential Knowledge Series), Andy Miah, MIT Pres
3. **Learning ROS for Robotics Programming** by Aaron Martinez

CO-PO Map

Course Outcomes	Program Outcomes												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2		3							2			3
2	3	2	2		3							2			3
3	3	2	2		3							2			3
4	3	2	2		3							2			3
5	3	2	2		3							2			3

Robotics & Artificial Intelligence

VI SEMESTER

MOTION CONTROL USING PLC

Course Code	**22RIL674**	CIE Marks	50
Teaching Hours/Week (L:T:P)	0-0-2	SEE Marks	50
Total Hours of Pedagogy	12	Total Marks	100
Credits	01	Exam Hours	02

Course objectives:

- To Implement basic gates and combinational circuits using PLC.
- To implement ON timer and OFF timer using PLC
- To implement UP counter and DOWN counter using PLC
- To implement real time applications using PLC

Course Outcomes: At the end of the course student will be able to

- Develop the Logical Instructions Involved in development of programmable logic controller for various operations
- Construct the ladder logic for various operations using PLC and SCADA for Industrial Environment

EXPERIMENTS
Design PLC ladder diagram for basic gate operation.
Design PLC ladder diagram for basic gate operation 2 Interfacing of Lamp & button with PLC for ON&OFF Operation. Verify all logic gates.
Design PLC ladder diagram for De-Morgan's theorem
Design PLC ladder diagram for 4:1 MUX and 1:4 DE-MUX
Design PLC ladder diagram for ON delay timer for ON/OFF controller of motor
Design PLC ladder diagram for OFF delay timer for ON/OFF controller of motor
Design PLC ladder diagram for UP COUNTER for ON/OFF controller of motor
Design PLC ladder diagram for DOWN COUNTER for ON/OFF controller of motor
Design PLC ladder diagram for ON and OFF delay timer for ON/OFF controller of motor with Micro Logix 1400
Design PLC ladder diagram for UP COUNTER and DOWN COUNTER for ON/OFF controller of motor withMicro Logix 1400

Design PLC based temperature sensing using RTD
Design temperature sensing using SCADA
Suggested Learning Resources: **Books** 1. “PLC and Industrial application”, Madhuchhandan Gupts and SamarjitSen Gupta, pernram international pub. (Indian) Pvt. Ltd., 2011. 2. Ronald L Krutz, “Securing SCADA System”, Wiley Publication **Reference Books** 1. GaryDunning,”Introduction to Programmable Logic Controllers”, Thomson,2 nd Edition. 2. John W Webb, Ronald A Reis,”Programmable Logic Controllers: Principles and Application”, PHI Learning, Newdelhi, 5 th Edition 3. Stuart A Boyer, “SCADA Supervisory Control and Data Acqusition”, ISA, 4 th Revised edition

CO-PO Map

Course Outcomes	Program Outcomes												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2		3				3	2		2	3		
2	3	3	3		3				3	2		2	3		
3	3	3	3		3				3	2		2	3		
4	3	3	3		3				3	2		2	3		
5	3	3	3		3				3	2		2	3		