AMRITA VISHWA VIDYAPEETHAM School of Engineering

DEEMED TO BE UNIVERSITY

(AMARAVATI, AMRITAPURI, BANGALORE, CHENNAI, COIMBATORE)

B. Tech Minor in Robotics and Automation

CURRICULUM AND SYLLABI

2023

Department of Mechanical Engineering

Minor: Robotics and Automation

Preamble:

Most industries have adopted Robotics and Automation to enhance productivity with high reliability, which demands a specialized workforce. In order to foster Engineering graduates at par with the current industry practices and requirements, a minor in Robotics and Automation is offered. This minor encompasses the essential courses necessary to build competence in understanding and solving challenges in design and implementation Robotics and Automation solutions in industries. The undergraduate curriculum in Engineering provides the necessary foundation in mathematics, computer programming, and machine learning, thereby enabling them to pursue the minor program. The comprehensive syllabus of the minor comprising of mechatronic systems, dynamics and control of robotic systems, and Industry 4.0 & Automation, captures the current trends in the industry, accentuating the need for a skilled and specialized workforce. This minor offers the necessary background for placement opportunities and pursuing research in Robotics and Automation.

List of courses for Minor in Robotics and Automation:

Minimum of 18 credits required for Minor programme

S.No.	Course Code	Name of the Course	Semester	L-T-P	Credits
Mandatory Courses (13 credits)					
1	23MEE231M	Actuators and Drives	3	3-0-0	3
2	23MEE232M	Robot Kinematics and Dynamics		3-0-0	3
3	23MEE233M	Microcontrollers and Embedded Systems		2-0-3	3
4	23MEE234M	Robotics and Control		3-0-3	4
Any two of the following courses can be selected in addition to above four courses for the minor program **(6 credits)**					
5	23MEE235M	Industrial Internet of Things		2-0-3	3
6	23MEE236M	Industrial Process Automation		2-0-3	3
7	23MEE237M	Mobile Robotics		2-0-3	3
8	23MEE238M	Real Time Operating Systems		2-0-3	3
9	23MEE239M	Drone Technology		2-0-3	3

SYLLABUS

23MEE231M **ACTUATORS AND DRIVES** **3-0-0-3**

A. Prerequisite: Nil

B. Nature of Course: Theory

C. Course Objectives:

1. Introduction of electrical and non-electrical actuators.
2. Sizing of pneumatic and hydraulic actuators.
3. The terminology, characteristics, and construction of electrical actuators
4. The classification of electric drives and their performance characteristics.
5. Selection of actuators and drives for robotics and automation applications.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Understand** the concepts of hydraulic, pneumatic and electrical actuators to industrial applications	Understand
CO02	**Determine** the specifications of hydraulic, pneumatic actuators for a given application	Apply
CO03	**Evaluate** the performance characteristics of electrical actuators	Evaluate
CO04	**Select** suitable actuators and drives for robotics and automation applications	Apply
CO05	**Analyze** the performance characteristics of drives for different actuators	Analyze

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	3													
CO02	3	3													
CO03	3	3	1												
CO04	3	3	1												
CO05	3	3	2		1										
Total	15	15	4		1										
Average	3	3	1		1										

F. Syllabus

23MEE231M ACTUATORS AND DRIVES 3-0-0-3

Unit 1

Pneumatic Actuators and Hydraulic Linear Actuator types - Single acting, Double Acting, Diaphragm, tandem, telescopic cylinder and cylinders with cushions. Rotary Actuator types - gear, vane, screw, piston types. Sizing of Actuators for industrial applications, Valves, Electro-hydraulic and Electro-pneumatic control devices. Symbols and circuits.

Unit 2

Introduction to Electrical actuators, Solenoids, Rotating electrical machines, operating principles, main terminology and industrial standards. DC, Synchronous, Induction, Stepper, BLDC, Servo motor: principle of operation, main characteristics and construction, Types, Starting, Speed Control and braking, Efficiency, Testing, Selection considerations.

Unit 3

Drives: Introduction, classification of electric drives, Dynamics of Electric drives: Types of loads, Multi quadrant operations, motor dynamics, steady state stability and transient stability. Electrical drives with DC, synchronous, induction, stepper, BLDC motors: Basic characteristics, Operating modes, Different control schemes. Gear boxes and harmonic drives. Case study/projects – automation and robotics applications.

Textbooks:

1. *S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education:New York, 2010.*
2. *Kothari D.P. and Nagrath I.J., "Electric Machines", Tata McGraw-Hill Publishing Company Limited, NewDelhi, 2004.Gopal K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2016.*

Reference Books:

1. *Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.*
2. *Pillay. S.K, A First Course on Electric Drives, Wilely Eastern Limited, Bombay, 2012*
3. *Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 2010.*
4. *Jagadeesha T., "Hydraulics and Pneumatics", 1st edition, I K International Publishing House, New Delhi, 2015*

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (50%)		
Quizzes	5	
Assignments	5	
Case Studies / Project	20	
Mid Semester Examination	20	
Semester End Examination [SEE] (50%)		
End semester exam	50	

23MEE232M	ROBOT KINEMATICS AND DYNAMICS	3-0-0-3

A. Prerequisite: Nil

B. Nature of Course: Theory

C. Course Objectives:

This course is expected to enable the students to
1. Analyze the forward and inverse kinematics of planar and spatial robots, developing techniques to compute its workspace.
2. Perform comprehensive and rigorous analysis of velocity Jacobians, kinematic singularities and kineto-static duality in mechanisms and robots.
3. Formulate the dynamic equation of motion for manipulator using Lagrange's equation.
4. Solve the dynamic equations of motion using different techniques.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	Understand the frame representation and spatial transformation	Understand
CO02	Derive the DH parameters and perform forward kinematic analysis	Analyze
CO03	Perform inverse kinematic analysis of robots	Analyze
CO04	Compute Jacobian matrix and solve the singularity problems of serial robot manipulators	Analyze
CO05	Apply the Lagrange's equation to derive the equations of motion	Apply
CO06	Analyze the dynamics of robot manipulator using Newton-Euler formulation	Analyze

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	3	2		1							1			
CO02	3	3	2	1	1							1			
CO03	3	3	2	1	1							1			
CO04	3	3	2		1							1			
CO05	3	3	2		1							1			
CO06	3	3	2		1							1			
Total	18	18	12	2	6							6			
Average	3	3	2	1	1							1			

F. Syllabus

23MEE232M — ROBOT KINEMATICS AND DYNAMICS — 3-0-0-3

Robot Kinematics

Introduction: Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot specifications, and programming. Spatial transformation. Homogeneous transformation of matrices – Representation of combined transformations – Inverse transformation of matrices.

Forward and inverse kinematics – position and orientation. Denavit Hartenberg (DH) representation of forward kinematic equations. Inverse kinematic solution of Robots. Degeneracy and Dexterity.

Differential Motions and Velocities – Linear and angular velocity of rigid bodies. Motion of the links of a robot – velocity propagation from link to link. Jacobians – singularity.

Robot Dynamics

Kinetics of rigid bodies – Work energy principle, Linear and angular momentum, conservation laws. Transformation from Newtonian to Lagrangian formulation – Principle of virtual work – Hamilton's principle – Lagrange's equation. Newton's equation, Euler equation. Iterative Newton – Euler dynamic formulation. Structure of manipulator dynamic equations. Lagrangian formulation of manipulator dynamics. Inclusion of nonrigid body effect. Dynamic simulation.

Textbooks:

1. Niku, Saeed B. Introduction to robotics: analysis, control, applications. John Wiley & Sons, 2020.
2. Craig, John J. Introduction to Robotics. Pearson Higher Ed, 2021.

Reference Books:

1. Spong, Mark W., and Mathukumalli Vidyasagar. Robot dynamics and control. John Wiley & Sons, 2008.
2. Shabana, Ahmed A. Computational dynamics. John Wiley & Sons, 2009.
3. Schilling RJ. Fundamentals of robotics: analysis and control. New Jersey: Prentice Hall; 1990 Jan.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (50%)		
Quizzes and open-ended Assignments	20	
Computational Exercises	10	
Mid Semester Examination	20	
Semester End Examination [SEE] (50%)		
End semester exam	50	

23MEE233M MICROCONTROLLERS AND EMBEDDED SYSTEMS 2-0-3-3

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. Introduction to microprocessor and microcontroller.
2. The performance metrics for processors in embedded systems.
3. The memory system design for cache and memory management.
4. The peripherals for communication with sensors and actuators.
5. The demonstration of ARM based controllers for application development in robotics and automation.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Identify** various hardware and software architectures in embedded systems	Understand
CO02	**Articulate** the concepts of microprocessors and microcontrollers	Evaluate
CO03	**Describe** the detailed architecture, internal modules and addressing modes of ARM based processor	Understand
CO04	**Analyze** microcontroller peripherals and interfacing of sensors and actuators	Analyze
CO05	**Develop** robotics and automation applications with microcontrollers	Analyze

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	3	2												
CO02	3	3	1												
CO03	3	3	1	2	1										
CO04	3	3	3	2	1										
CO05	3	3	3	3	3							1			
Total	15	15	10	7	5							1			
Average	3	5	2	2	2							1			

F. Syllabus

23MEE233M MICROCONTROLLERS AND EMBEDDED SYSTEMS 2-0-3-3

Unit 1

Introduction to Embedded Systems; Architecture – Sensors, Processor: Microprocessor & Microcontroller, Actuator; Classifications of embedded systems; Design process; Applications; Processor - evolution and types. CPU Performance, Performance Metrics and Benchmarks.

Unit 2

An introduction to Embedded Processors. ARM Architecture – Programmer's Model, Instruction Set, Addressing modes, Assembly Programs. Pipelined data path design - Pipeline Hazards. Memory system design- Cache Memory, Memory Management unit, Virtual Memory.

Unit 3

Overview of 8-bit and 16-bit microcontrollers. Introduction to ARM based Microcontrollers – Architecture, Peripherals - Input/output ports, Timers, ADC, DAC, PWM, Quadrature Encoder, UART, I2C, SPI, Advanced communication interfaces. Interfacing of sensors and actuators. Application development – Robotics & Automation.

List of Experiments:

1. Familiarization of IDE, simulator, development boards and kits
2. Assembly Language Programs
3. Embedded C Program to configure and use Input/output ports & Timers
4. Embedded C Program to configure and use ADC and DAC
5. Embedded C Program to configure and use PWM
6. Embedded C Program to configure and use UART
7. Embedded C Program to configure and use SPI
8. Embedded C Program to configure and use I2C
9. Interfacing of sensors and actuators to microcontroller
10. Development of robotic and automation applications

Textbooks:

1. Yifeng Zhu, "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C". Third Edition, E-Man Press LLC, 2017.
2. Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
3. Joseph Yu, "The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors", Third Edition, Newness, 2013.

Reference Books:

1. ARM Technical Reference Manual (https://developer.arm.com/documentation/)
2. ARM Architecture Reference Manual (https://developer.arm.com/documentation/)
3. NXP LPC 17xx user manual (https://www.nxp.com/docs/en/user-guide/UM10360.pdf)
4. Getting started with MDK Create applications with µVision® for ARM® Cortex®-M microcontrollers
5. (https://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2)
6. Steve Furber, "ARM System-on-chip Architecture", Second Edition, Addison Wesley, 2000.
7. Andrew Sloss, Dominic Symes and Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufumann Publisher, 2011.
8. William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
9. ARM Technical Reference Manual, NXP LPC 17xx datasheet.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / Project	40	

23MEE234M	**ROBOTICS AND CONTROL**	**3-0-3-4**

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. The fundamental knowledge of robotics, characteristics, workspace specifications, and systems.
2. The development of various formulations to describe dynamic models of robotic systems.
3. The comprehensive and rigorous treatment of concepts and principles related to manipulator dynamics and trajectory planning.
4. The various strategies for trajectory planning and motion control of manipulator.
5. The programming and visualization of manipulator dynamics through software and hardware.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Outline** the fundamentals of robotics and its components	Understand
CO02	**Solve** for the manipulator dynamics using Lagrangian formulation.	Evaluate
CO03	**Implement** the various trajectory planning algorithms and control techniques	Analyze
CO04	**Solve** the forward and inverse dynamics problems of robotics	Analyze
CO05	**Apply** different nonlinear and force control algorithms for robot control.	Apply

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO01	3	3	3									1			
CO02	3	3	3		1							1			
CO03	3	3	3		1							1			
CO04	3	3	2		1							1			
CO05	3	3	3		1							1			
Total	15	15	14		4							5			
Average	3	3	3		1							1			

F. Syllabus

23MEE234M	ROBOTICS AND CONTROL	3-0-3-4

Unit 1

Application of Robots. End Effectors-Grippers-Types: Pneumatic, Hydraulic, Magnetic, Vacuum Grippers; Selection and Design Considerations. Gripper Force analysis. Resolution, accuracy and repeatability of robot, applications. Static forces in manipulator. Jacobian in the force domain.

Unit2

Manipulator Dynamics: Lagrangian Mechanics, Dynamical models of multiple DOF robots, robot workspace analysis, Static force analysis of robots, Transformation of forces and moments between coordinate frames. Dynamic algorithms and Introduction to recursive robot dynamics.

Trajectory Planning: Robot workspace analysis, joint space trajectories, path and trajectory planning of a robot, Trajectory Interpolation, Set point tracking, Actuator Dynamics. Cartesian-Space Trajectories, Continuous trajectory recording

Unit 3

Motion Control: The control problem, Joint space control, Decentralized control, Computed torque feed forward control, Centralized control, PD Control with gravity compensation, Inverse dynamics control, Operational space control. Nonlinear decoupled feedback control, resolved motion control, robust control, adaptive control, Force control, hybrid control, control of robot trajectory. Robot programming languages. Introduction to motion control in mobile robotics.

List of Exercises:

1. Dynamic modelling and analysis of an industrial robot manipulator.
2. Trajectory Planning of 3R robot based on 3rd order polynomial trajectory
3. Computation of geometric Jacobian for robot manipulator.
4. Trajectory tracking control of industrial robotic arm using robot manipulator blocks
5. Rotational and transform trajectory analysis of robot manipulator
6. Trapezoidal velocity profile trajectory analysis of robot manipulator
7. Visualization of manipulator trajectory tracking in 3D.
8. Design and develop the manufacturing cell using virtual robot simulator.
9. Develop a TCP and work-object for Industrial Robot using Robot simulator.
10. Develop the robot programming for pick and place of objects, material handling and welding operations.
11. Singularity analysis using Robot simulator.
12. Interface and configure the vision system with Industrial Robot.
13. Part identification based on colour & pattern and separate the components using vision system and Robot.
14. Develop a program to draw a pattern using the manipulator.
15. Program the robot manipulator's end effector to travel along a complex 3D path.

Textbooks:

1. Craig, J.J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, Reading, MA, 1989.

Reference Books:

1. L. Sciavicco, B. Siciliano, Modeling and Control of Robot Manipulators, Springer, 2002.
2. Angeles, J., Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, NY, 1997.
3. Fu, Gonzales, and Lee, Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill, 1987.
4. Shames,I.H, "Engineering Mechanics-Statics and Dynamics", 4/e, Prentice-Hall of India Pvt. Ltd., 2005

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / project	40	

23MEE235M	**INDUSTRIAL INTERNET OF THINGS**	**2-0-3-3**

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. The fundamental knowledge on industrial trends and revolutions.
2. The industry standards in communication technology and various communication protocols.
3. The visualization and data types in communication for the Industrial Internet of Things (IIoT).
4. The demonstration of different wireless communication schemes and experimental validation.
5. The programming the edge or fog computing node and visualization of sensor data.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Describe** the concepts and characteristics of Industry 4.0.	Understand
CO02	**Comprehend** different enabling technologies and their role in establishing Industry 4.0.	Evaluate
CO03	**Understand** different communication technologies used in Industry 4.0.	Understand
CO04	**Perform** edge and cloud computing and visualize the data.	Analyze
CO05	**Apply** IoT for the given applications.	Apply

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	2	1		2							1			
CO02	3	2	1		2							1			
CO03	3	2	2		2		1					1			
CO04	3	2	3		2	2	2					1			
CO05	3	2	2		2	2	2			1		1			
Total	15	10	9		10	4	5			1		5			
Average	3	2	2		2	2	1			1		1			

F. Syllabus

23MEE235M	**INDUSTRIAL INTERNET OF THINGS**	**2-0-3-3**

Unit 1

Introduction: The various industrial revolutions, digitalization and the networked economy, drivers, enablers, comparison of industry 4.0 factory and today's factory, challenges. Cyber Physical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Mobile Computing, Cyber Security, Augmented / Virtual reality, Artificial Intelligence, System integration, Digital twins. Introduction to Industry 5.0.

Unit 2

Communication Technologies of IIoT
Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID, Industry standards communication technology (LoRA, WAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network.

Unit 3

Visualization and Data Types of IIoT communication.
Front-end EDGE devices, Emerging descriptive data standards for IIoT, Cloud data base, could computing, Fog or Edge computing. Pushing data to cloud. Grabbing the content from a web page, sending data on the web, Troubleshooting. **Application of IIOT.**

Case study: Health monitoring, smart city, Smart irrigation, Robot surveillance.

List of Experiments:

1. Introduction to Arduino, and ESP8266 (Node MCU)
2. Introduction to Raspberry Pi and Installation of OS
3. Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Raspberry Pi/Node MCU
4. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry Pi/Node MCU
5. Measurement of temperature & pressure values of the process using Raspberry Pi/Node MCU
6. Demonstration of MQTT communication
7. Demonstration of LoRa communication
8. Visualization of diverse sensor data using dashboard (part of IoT's 'control panel')
9. Sending alert message to the user (ways to control and interact with environment)
10. Device control using mobile Apps or through Web pages
11. Machine to Machine communication

Textbooks:

1. Klaus Schwab, "The Fourth Industrial Revolution", Portfolio Penguin, 2017.
2. Bruno S.Sergi, Elena G.Popkova, Aleksei V. Bogoviz and Tatiana N. Litvinova, " Understanding Industry 4.0: AI, The internet of things, and the future of work", Emerald publishing limited, 2019.

Reference Books:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
2. Kaushik kumar, DivyaZindani, J. Paulo Davim, "Digital manufacturing and assembly systems in Industry 4.0", CRC Press, Taylor and Francis group, 2020.
3. Antonio sartal, Diego Carou, J.PauloDavim, " Enabling technologies for the successful deployment of Industry 4.0, CRC press, 2020.
4. Alp Ustundag, Emrecavikcan, "Industry 4.0: Managing the digital transformation", Springer International publishing, 2018.
5. Christoph Jan Bartodziej, "The Concept Industry 4.0", Springer Gabler, 2017.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / Project	40	

23MEE236M	INDUSTRIAL PROCESS AUTOMATION	2-0-3-3

A. Prerequisite: Nil

B. Nature of Course: Theory

C. Course Objectives:

1. The fundamentals of PLC, SCADA and DCS for data handling
2. The programming languages and skills for PLC and SCADA
3. The different architectures for computer based automation and HMI development
4. The design of a graphical system using virtual instrumentation software

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Develop** the PLC program for the given application	Apply
CO02	**Interface** the Input and output devices with PLC	Evaluate
CO03	**Apply** the concepts of SCADA for industrial automation	Apply
CO04	**Analyze** the communications and networking of distributed control systems	Analyze
CO05	**Design** a graphical system using Virtual Instrumentation software	Apply

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO3
CO01	3	2	3		2							2			
CO02	3	2	3		2							2			
CO03	3	2	3		2							2			
CO04	3	2	3		2							2			
CO05	3	2	3		2							2			
Total	15	10	15		10							10			
Average	3	2	3		2							2			

F. Syllabus

23MEE236M	INDUSTRIAL PROCESS AUTOMATION	2-0-3-3

Unit 1

Programmable Logic Controllers: Introduction, Types of PLC, CPU unit architecture, Memory classification, Input/output devices and their interfacing, Digital-Analog modules, Communication modules, Special function modules, Basic Ladder logic, electrical wiring diagram, scan cycle. Programming languages for PLC, PLC module addressing, registers basics, basic relay instructions, timer-counter instructions, Math functions, data handling, and program control instructions.

Unit 2

SCADA: Introduction to computer-based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS), and supervisory control and data acquisition (SCADA) based architectures and HMI Components, HMI Development, Data Processing, Control Algorithm, Programming, Data Acquisition from PLCs/RTUs, Database Connectivity and Report generation. OPC Configuration with RTUs (PLC), Cyber Security for Industrial Control Systems.

Unit 3

Distributed Control System- Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data. **Introduction to Virtual Instrumentation**, Traditional and virtual instruments. Data types, G-Programming, Concept of VIs and sub-VIs, Graphs and charts, Local and Global variables – String and file I/O, Control loops and structures, sequence structures, and Data acquisition system. Signal processing and analysis, Graphical system design.

List of Experiments:

1. Ladder programming for boolean operations & math operations
2. Interfacing of Electro-Pneumatic system with PLC
3. Speed control of DC motor using PLC
4. Interfacing HMI with PLC
5. Interfacing PLC real-time TAG with SCADA
6. Flow and pressure measurement and control using SCADA
7. Develop a SCADA screen program for process plant operation
8. Develop a database and recipe TAG base in SCADA
9. Basic programming using Virtual Instrumentation software
10. Data acquisition and processing using Virtual instrumentation software
11. Graphical system design using Virtual Instrumentation software

Textbooks:

1. *Lukas M.P, "Distributed Control Systems," Van Nostrand Reinhold Co., New York, 1986.*
2. *Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005.*
3. *Gupta, Virtual Instrumentation Using LabVIEW 2E,* Tata McGraw-Hill Education, 2010

Reference Books:

1. Elshafei, M., 2016. *Modern Distributed Control Systems: A comprehensive coverage of DCS technologies and standards*. CreateSpace Independent Publishing Platform.
2. Mehra, R., 2012. *PLCs & SCADA: Theory and Practice*. Laxmi Publications.
3. Jennings, R. and De La Cueva, F., 2020. *LabVIEW graphical programming*. McGraw-Hill Education.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
CA Theory	10	
CA Lab	40	
Mid Semester Examination	10	
Semester End Examination [SEE] (40%)		
End semester exam / Project	40	

23MEE237M	**MOBILE ROBOTICS**	**2-0-3-3**

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. The fundamental knowledge on the essential elements of robotic locomotion.
2. The challenges and techniques in realizing robotic locomotion.
3. The comprehensive and rigorous treatment of concepts on path planning and navigation.
4. The basics of robot learning and collective robotics.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Derive** the mathematical models and describe motion control methods	Understand
CO02	**Apply** various models of localization and navigation.	Apply
CO03	**Analyze** locomotion challenges and select motion planning algorithms.	Analyze
CO04	**Design** and develop autonomous mobile robots with obstacle avoidance.	Evaluate

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	**Program Outcomes [POs]**												**Program Specific Outcomes [PSOs]***		
	PO 1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO01	3	3	3									1			
CO02	3	3	3		1							1			
CO03	3	3	3		1							1			
CO04	3	3	2		1							1			
Total	12	12	11		3							4			
Average	3	3	3		1							1			

F. Syllabus

23MEE237M	**MOBILE ROBOTICS**	**2-0-3-3**

Unit 1

Introduction to autonomous robotics, terrestrial and aerial locomotion, mobile robot kinematic models, manoeuvrability, workspace, and kinematic control. Perception – non-visual sensors and algorithms, computer vision, image processing, feature extraction – interest point detectors, range data.

Unit 2

Mobile robot localization, Noise and aliasing, belief representation, probabilistic map-based localization – Markoc and Kalman filter localization, Autonomous map building, SLAM paradigms - Extended Kalman filter, graph-based and particle filter. Sensorial, geometric and topological maps, robot collectives – Sensing, communication, formation control, localization and mapping.

Unit 3

Planning and Navigation: Path planning. Graph search – Voronoi diagram, deterministic graph search, Dijkstra's algorithm, A*, D* algorithm, Randomized graph search, Potential field path planning. Obstacle avoidance – Bug algorithm, Techniques viz. bubble band, curvature velocity, dynamic window approach, Schlegel approach, gradient method, Mobile robots in practice, delivery robots, intelligent vehicles, mining automation, space robotics, underwater inspection.

List of Experiments:

1. Design and simulation of a biped robot.
2. MATLAB/Python programming for kinematic control of differential drive vehicle.
3. Line fitting and range data feature extraction.
4. Line-based Kalman filtering for mobile robot localization,
5. Simultaneous localization and mapping based on Extended Kalman Filtering.
6. Simulate a system of collective robots for arbitrary inputs and constraints,
7. Mobile robot path planning with global and local dynamic window approaches.
8. Noise rejection navigation simulation for mobile robot

Textbooks:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza. (2011). Introduction to Autonomous Mobile Robots. 2nd edition, The MIT Press.
2. Gregory Dudek, and Michael Jenkin. (2010). Computational Principles of Mobile Robotics. Second edition, Cambridge University press

Reference Books:

1. Ulrich Nehmzow, (2012). Mobile Robotics: A Practical Introduction Second Edition. Springer.
2. Peter Corke (2017). Robotics, Vision and Control Fundamental Algorithms in MATLAB®. Second Edition. Springer
3. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun (2005) Principles of Robot Motion Theory, Algorithms, and Implementation, MIT press.
4. Sebastian Thrun, Wolfram Burgard, Dieter Fox. (2002) Probabilistic Robotics. The MIT press.
5. Steven M. LaValle. (2006). Planning Algorithms, Cambridge University Press.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / project	40	

23MEE238M	REAL TIME OPERATING SYSTEMS	2-0-3-3

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. The fundamental knowledge on the real-time operating system (RTOS).
2. The various approaches to real-time scheduling and other kernel services.
3. The comprehensive and rigorous treatment on task communication and synchronization.
4. The essential elements of Robot Operating System (ROS).

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Identify** the basic concepts in real time systems	Understand
CO02	**Apply** various services provided by the RTOS Kernel	Apply
CO03	**Analyze** various algorithms of RTOS kernel services.	Analyze
CO04	**Develop** real time applications using ROS framework.	Evaluate

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	3													
CO02	3	3													
CO03	3	3	2												
CO04	3	3	3	1											
Total	12	12	5	1											
Average	3	3	3	1											

F. Syllabus

23MEE238M	REAL TIME OPERATING SYSTEMS	2-0-3-3

Unit 1

Overview of concepts of Operating System, GPOS functionalities, Architecture of OS (Monolithic, Microkernel, Layered, Exokernel and Hybrid kernel structures). Evolution of operating systems. Introduction to real-time systems, RTOS basic architecture, RTOS vs GPOS. POSIX Standards. RTOS Kernel, Kernel services.

Unit 2

Task Management - Tasks, process and threads, task attributes and types - task states and transition, preemption-context switching, task control block, Introduction to real-time task scheduling, clock-driven and priority-driven scheduling, uniprocessor scheduling and multiprocessor scheduling concepts. Blocking, Deadlock and avoidance strategies, priority inversion and solutions. Task Communication and Synchronization - Semaphores and Mutex, Mailbox, Queue, Pipes. Timer Management, Interrupt handling, Memory Management – Cache and Virtual Memory, Input-Output handling.

Unit 3

Familiarization of ROS – architecture, sensors and actuators supported, computing platforms. Experiment on Creating, building, modifying packages and Writing, building source code and nodes, Creating and Running Publisher, Subscriber Nodes, Service Servers, Client Nodes, Action Server and Client Node. Programming experiment on nodes with setting, reading, building, running, displaying parameters list. Programming with ROS.

List of Experiments:

1. ROS launch
2. 3D visualization tool (RViz)
3. Design and development of graphical user interface in ROS environment.
4. Establish communication between robot client and server
5. Analysis of data packet loss Visualization of robot and their movements in Rviz ROS.

Textbooks:

1. Qing Li, Caroline Yao, "Real-Time Concepts for Embedded Systems" First Edition, CRC Press, 2010.
2. Douglas Wilhelm Harder, Jeff Zarnett, Vajih Montaghami and Allyson Giannikouris, "A practical introduction to real-time systems for undergraduate engineering", First Edition, University of Waterloo, 2015.

Reference Books:

1. Tanenbaum, "Modern Operating Systems," Fourth Edition, Pearson Edition, 2014.
2. Jane W.S. Liu, "Real -Time Systems", First Edition, Pearson Education, 2000.
3. Lentin Joseph, "Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy", First Edition, Apress, 2018.
4. Kumar Bipin, "Robot Operating System Cookbook", First Edition, Packt Publishing, 2018.

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / project	40	

23MEE239M DRONE TECHNOLOGY 2-0-3-3

A. Prerequisite: Nil

B. Nature of Course: Lab Integrated

C. Course Objectives:

1. The basic concepts of drones, propellers and controls of drones.
2. Kinematic, dynamics and modeling of multi robot micro drones.
3. The various approaches for state estimation.
4. The comprehensive and rigorous treatment on path planning of drones.

D. Course Outcomes:

After successful completion of the course, Students will be able to:

S.No.	Course Outcomes	Knowledge level [Bloom's Taxonomy
CO01	**Solve** the kinematics and dynamics of fixed wing drones	Understand
CO02	**Solve** the kinematics and dynamics of multi rotor micro drones.	Evaluate
CO03	**Design** the flight controls of drones.	Understand
CO04	**Design** and develop path planning algorithms for drones	Analyze

E. CO-PO Mapping: [affinity#: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]											Program Specific Outcomes [PSOs]*		
	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO01	3	3		3	2							1			
CO02	3	3		3	2							1			
CO03	3	3	3	3	3							1			
CO04	3	3	3	3	3							1			
Total	12	12	6	12	10							4			
Average	3	3	3	3	3							1			

F. Syllabus

23MEE239M DRONE TECHNOLOGY 2-0-3-3

Unit 1

Fixed Wing and Multirotor Micro Drones: Introduction – Drones – Kinematic and dynamics modelling formulation of drones - Transformation and representations – Dynamics of a fixed-wing drones, Propeller theory – Thrust and drag moment – Dynamics of a multi rotor micro drones (MMD) – Mathematical modelling of MMD

Unit 2

State Estimation: Physics and working of navigational sensors – Inertial Sensors – Magnetometer – Pressure sensors, GPS – Camera based navigation – Kalman filter – Position and velocity analysis, Inertial navigation systems – Attitude estimation

Unit 3

Flight Controls and Motion Planning: PIC control – Lateral control of MMD, LQR – Design of servo LQR control, Linear model predictive control – Design and implementation. Holonomic vehicle boundary value solver, Dubins airplane model boundary value solver – collision free navigation, Structural inspection path planning

Textbooks:

1. R. Beard, and T. W. McLain, "Small Unmanned Aircraft: Theory and Practice", Princeton University Press, 2012
2. R. C. Nelson, "Flight Stability and Automatic Control", McGraw Hill, New York, 1998.

Reference Books:

1. L.R. Newcome, Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston, 2004.
2. Kuo, B. C., "Automatic Control Systems", Prentice Hall, 1991

G. Evaluation Pattern:

Component	Weightage	Remarks
Cumulative Internal Examination [CIE] (60%)		
Mid Semester Examination	20	
Continuous Assessment (CA) - Theory	10	
Continuous Assessment (CA) - Lab	30	
Semester End Examination [SEE] (40%)		
End semester exam / project	40	

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