Minor Specialization offered by Mechanical Engineering department with ECE dept.: Industrial Automation									
S. No.	**Course Code**	**Dept.**	**Sem.**	**Course Title**	Contact Hours				**Credits**
					L	T	P	Total	
1	EC334	ECE	IV	Transducers Engineering	3		-	3	3
2	EC401	ECE	IV	Transducers Engineering Lab	-	-	2	2	1
3	ME350	MEC	V	Robotics	3	-	-	3	3
4	EC335/ EC340	ECE	V	Digital Control System	3	-	-	3	3
5	ME401	MEC	V	Robotics/CIM Lab	-	-	2	2	1
6	ME351	MEC	VI	Industrial Automation	3	-	-	3	3
7	ME352	MEC	VI	Control of Industrial Automation	3	-	-	3	3
8	ME353	MEC	VII	Special Purpose Vehicle	3	-	-	3	3
				Total	24	-	4	28	**20**

Minor Specialization offered by Mechanical Engineering department with ECE dept.: Mechatronics									
S. No.	**Course Code**	**Dept.**	**Sem.**	**Course Title**	Contact Hours				**Credits**
					L	T	P	Total	
1	EC334	ECE	IV	Transducers Engineering	3		-	3	3
2	EC401	ECE	IV	Transducers Engineering Lab	-	-	2	2	1
3	ME354	MEC	V	Vehicle Dynamics	3	-	-	3	3
4	ME355	MEC	V	Computer Integrated Manufacturing	3	-	-	3	3
5	ME402	MEC	V	CIM Lab	-	-	2	2	1
6	ME356	MEC	VI	Control of Mechanical System	3	-	-	3	3
7	EC335	ECE	VI	Micro-controller and Embedded System	3	-	-	3	3
8	ME357	MEC	VII	Automated Guided Vehicles	3	-	-	3	3
				Total	24	-	4	28	**20**

Course Description

Title: Robotics **Code: ME350**

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students should have knowledge of courses "Engineering Mechanics, Engineering Drawing and Design and Theory of Machines".

Objective:

1. To learn and know about the anatomy of robots and how to perform robots.
2. To develop the abilities to write a program for a typical application of robot.

Learning Outcomes:

Course Outcome	Description
CO1	Outline the terminology, components and subsystems of robots.
CO2	Describe the working principles of drive system, end effectors, sensor, and machine vision systems of robots.
CO3	Develop an idea to modify the motions or working of different joints and links in any robotic system.
CO4	Identify the most influencing parameters to fabricate the robotic system.
CO5	Apply appropriate technique to analyze the robot kinematics.
CO6	Demonstrate and deployment the skills to write the program for real world applications of robot.

COURSE CONTENT:

Unit-1: Introduction: Past, Present & Future, Robot anatomy, Work volume, Applications, Components and Subsystems, Classification of robot.

Unit-2: Robot technology: robot and its peripherals- Basic control system concepts and model, controllers, End effectors, Different types of grippers and design concepts.

Unit-3: Robot Drives, Actuators and Control Drive systems: Hydraulic, Pneumatic and Electrical. DC motor, Stepper motor, Robot motion, and Path control, Controller.

Unit-4: Robot Kinematics, Object location: Homogenous, Transformations.

Unit-5: Direct and Inverse kinematics, Dynamics of robots, Manipulator motion.

Unit-6: Sensors and Perception- Types of sensors, Vision system, Computer Interfaces, Robot Programming.

Teaching Methodology:

This course is introduced for helping students how to tasks are performed by mechanical manipulators (Robots) in the industries. The entire course is broken down into six separate units: Robot terminology, Applications, Components and Subsystems, classification, grippers, actuators, controllers, Sensors, Kinematics and dynamics of robots, and robot programming.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1 and Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Robotics Engineering (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

[1] “Robotics Technology and Flexible Automation”, S. R. Deb, S. Tata McGraw Hill Education Pvt. Ltd, 2010.

[2] “Introduction to Robotics”, John J. Craig, Pearson, 2009.

[3] "Industrial Robots - Technology, Programming and Applications", M. P. Groover, M. Weiss, R. N. Nagal, N.G. Odrey, A. Dutta, McGraw Hill, New York, 2008.

Reference Books/Material:

[1] "Robotics Engineering – An Integrated Approach", Richard D Klafter, Thomas A Chmielewski, Michael Negin, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

[2] "Robotics : Control, Sensing, Vision and Intelligence", Fu K S, Gonzalez R C, Lee C.S.G, McGraw Hill, 198

Web References: https://nptel.ac.in/courses/112/105/112105249/

Course Description

Title: Robotics/CIM LAB **Code : ME401**

L-T-P Scheme: 0-0-2 **Credit: 1**

Prerequisite: Students should have knowledge of courses "Engineering Mechanics, Engineering Drawing and Design, Theory of Machines and CAD/CAM".

SCOPE AND OBJECTIVES

- This course is designed to provide practical experience to students with an opportunity of hands-on training on CIM system including CNC machine tools and robots.
- The topics covered in this course include the basics of automation, NC programming (Manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics etc.
- The objective of this course is to expose the students to practical aspects of automation and the state-of-the-art technological developments in the area of modern manufacturing.

LEARNING OUTCOME

After completion of this course, the students will have:

- Knowledge and operational experience of CNC lathe and milling part programming.
- Knowledge and operational experience of programming for robots and CMM
- Capability to comprehend the functioning of various components of the automation and CIM.

LEARNING OUTCOME:

Course Outcome	Description
CO1	Outline the components and subsystems of robots and basic concepts related to CIM like types of production, automation and FMS.
CO2	Describe the functioning of drive system, end effectors, sensor, and machine vision systems of robots and computer aided process planning (CAPP) and Automated inspection.
CO3	Develop ability to write CNC part programs, formation of part families, pick and place programs for robot and automated inspection through CMM.
CO4	Identify the sequence of operation, generate process plan and simulate the FMS operation in off-line mode.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in Robotics/CIM lab of the department.

CO6	Demonstrate ability to work in a flexible manufacturing system in an organization.

COURSE CONTENT

5-axis and 6-axis Robot

1. Introduction to 5 and 6 axis robot and basic operations. Write a simple program for pick and place operation for 5-axis robot.
2. Write program for pick and place operation for repetitive cycle for 5-axis robot.
3. Write a program for continuous welding operation for 6-axis robot.
4. Write and practice programming on 6-axis robot.

XL Turn Machine

5. Write a manual part program for Linear and Circular Contour (G01, G02, and G03) operation for the component. Write a manual part program for Box Facing (G94) operation for the component.
6. Write a manual part program for Multiple Facing (G72) operation for the component. Write a manual part program for Multiple Turning operation with G71 Cycle for the component.
7. Write a manual part program for Peck Drilling operation with G74 Cycle for the component.
8. Write a manual part program for Turning and Parting OFF operation through subroutines for the component.

XL Mill Machine

9. Write a manual part program for Contouring (G01, G02, and G03) operation (Linear & Circular Interpolation) for the component. Write a manual part program for Contouring (G40, G41) operation with Left cutter diameter compensation for the component.
10. Write a manual part program for Contouring (M98, M99) operation through subprogram for the component. Write a manual part program for Mirroring (M70, M71, M80, and M81) operation for the component.
11. Write a manual part program for Drilling (G73, G83, G98, and G99) operation for the component.
12. Write a manual part program for Pocketing (G170, G171) operation for the component.

Coordinate Measuring machine (CMM)

13. Write a program for automatic measurement of various dimensions such as OD, ID, thickness etc. of a part.

Complete CIM System

14. Demonstration and study of CIM system Off-line and on-line mode.

TEXT BOOK:

1. Robot programming Manual by MTAB, Chennai
2. CNC XLTURN Manual by MTAB, Chennai
3. CNC XLMILL Manual by MTAB, Chennai
4. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.

1. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

Course Description

Course Name: Industrial Automation **Course Code: ME351**

L-T-P: 3-0-0 **Credits: 3**

Prerequisite: Basic of electrical and electronics engineering, fluid mechanics, kinematics, thermodynamics.

Objective:

1. This course is a combination of mechanics, electronics and pneumatic/hydraulic.
2. To impart interdisciplinary knowledge to study conveyors, overhead cranes, robots, pneumatic/hydraulic controls, motors and PLC etc.
3. The aim of the course is to make a bridge among various engineering disciplines such as Mechanical, Electronics, Instrumentation, Computer and Control to understand automation in industries.

Learning Outcomes:

CO1	Outline of Automated systems to understand the requirement of automation
CO2	Describe various sensors, signal processing, motors, conveyors, robots, PLC, pneumatic and hydraulic systems
CO3	Develop the knowledge of automation to improve the performance of manufacturing, maintenance and assembly units
CO4	Identify the type of sensors, signal conditioning methods and actuators required for specific problem of automation
CO5	Apply the knowledge to develop and maintain various automation systems
CO6	Demonstrate the skill in the field of requirement

Course Content:

UNIT–I: Automation: Advantages, disadvantages, factory and manufacturing environment.

Sensors: Performance terminology, displacement, velocity, acceleration, force, temperature, pressure, flow, light, position and proximity sensors. Signal conditioning and data acquisition.

UNIT- II: Controllers: Open loop control, close loop control, proportional, derivative, integral, PID and adaptive control.

Motors and Conveyors: DC motors, AC motors, stepper motors and servo motors. Belt conveyors, roller conveyors, chain and mat conveyors, indexing and synchronous machines, overhead cranes and industrial robots.

UNIT-III: Pneumatics and Hydraulics: Flow control, pressure control, none-return, direction and logic control valves. Timers, pressure sequence, counter valves and limit switches. Pneumatic and hydraulic actuators. Multi-actuator circuits, cascade and shift register methods. Solenoid valves, relays, switches, logic control, memory functions, electrical timers and counters, pressure switches.

UNIT–IV: Programmable Logic Controllers (PLC): Basic structure, input output processing, ladder programming, instruction list, latching, internal relays, sequencing, timers, counters, shift registers, master and jump controls and data handling.

Industrial Safety: Hazard analysis, emergency stops, physical guarding, lockout/ tagout, design mitigation, guard devices, software and intrinsic safety.

Teaching Methodology:

The course will start from the architect of Automated systems such as inputs and outputs of any physical system. It includes different variety of sensors and the processing of the signals. Also different variety of actuators used in automated systems in the industry to get the required process. It is also required to know the basics of electrical motors and their controls, various modes of controls, conveyors and industrial robots.

In the field of automation pneumatics and hydraulics have their importance. Hence, in this subject different compressor, oil pumps introduction will be given. Different varieties of direction control valves are to be talked to achieve the required action by the actuators. It also includes different architect of the circuits to achieve the required job done. To further enhance the performance of the automation electro-pneumatics will come in action. Further it can be done to the electro-pneumatics system by incorporating programmable logic controller. It is also deal with various aspects of industrial safety.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit Iand II
Test-2	25 Marks	Based on Unit II, III and syllabus of T1 (20%)
Test-3	35 Marks	Based on Unit III, IV, syllabus of T1 (15%) and

		syllabus of T2 (15%)
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes on Mechatronics and Automation (will be added from time to time): Digital copy will be available on the JUET server.

Text Book:

1. HMT Ltd, Mechatronics, Tata McGraw Hill.
2. Industrial Automation, McGraw Hill Education

References Books/Materials:

1. Isermann R., Mechatronics Systems: Fundamentals, Springer.
2. Bradley, D. A., Dawson, D., Buru, N. C. and Loader, A. J., Mechatronics, Chapman and Hall.
3. Bolton W., Mechatronics, Pearson Education.

Web References:

1. www.youtube.com/user/nptelhrd

Journals References:

1. International Journal of Mechatronics and Automation

Course Description

Title: Control of Industrial Automation **Code: ME352**

L-T-P scheme: 3-0-0 **Credit: 3**

Objectives

1. The objective of this course is to impart knowledge about automation in production systems.
2. To make students learn the important theoretical concepts, and the state-of-the-art technological developments in the area of automated manufacturing.
3. Various topics to be covered are basics of automation, NC and CNC technologies, concepts of group technology, Flexible Manufacturing system, CIM and robotics, CAPP, CMM, 3D scanners, automated assembly, Reverse engineering and fundamentals of 3D printing.

Learning Outcome

Course Outcome	Description
CO1	Outline and fundamentals of Industrial automation and importance of automation in Industry 4.0.
CO2	Describe concepts of various types of automation in industries. NC and CNC technologies.
CO3	Develop concept of group Technology, FMS and its components.
CO4	Identify the scope of application of automated assembly, Computer aided process planning and other inspection techniques by studying fundamentals of the same.
CO5	Apply the line balancing algorithms to balance the automated assembly lines. Basic fundamentals of 3D printing and its classification, file formats etc.
CO6	Demonstrate skill to apply reverse engineering in association with 3D printing to create customized parts. 3D printing applications.

Course Brief:

Introduction to Automation: Introduction to Production Systems; Automation in Manufacturing and Production Systems: Fixed, Flexible and Programmable Automation, Automation strategies, levels of Automation; Product Development Process and Automation.

Flexible Manufacturing System: Fundamentals of NC and CNC Technology; Concept of Group Technology and Cellular Manufacturing; Flexible Manufacturing Systems and its Components: Workstations, AS/RS, Automated Transport System; Fundamentals of Robotic Systems and Applications.

Computer Aided Process Planning (CAPP): Introduction to process planning, CAPP, generative and retrieval type CAPP.

Automated assembly systems: Design for Automated Assembly, Assembly Line Balancing and examples.

Reverse Engineering: Definition, Scanning and Processing of Raw Data, Creation of CAD Models;

Introduction to Contact and Non-Contact Type Scanners, Types of 3D Optical Scanners and Coordinate Measuring Machine (CMM).

Introduction to 3D Printing: Definition, Processing Steps, Classification, Applications and File Formats for 3D Printing Technology.

Teaching Methodology:

This course is introduced to help students learn and understand various automation techniques being used in Industries. Students will be taught fundamentals of automation and its types, basics of NC and CNC technologies, Group technology, FMS, CAPP, automated assembly, and design for excellence, contact and non contact types inspections techniques, CMM, 3D scanners, reverse engineering, fundamental of 3D printing technology, its classification, material and applications. Although, the course is not complemented by any lab course; students will be taken occasionally to lab for hands on experience.

Evaluation Scheme:

Exams	**Marks**
Test-1	15 Marks
Test-2	25 Marks
Test-3	35 Marks
Assignment	10 Marks
Tutorials	5 Marks
Quiz	5 Marks
Attendance	5 Marks
Total	**100 Marks**

Text Books:

1. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
2. Chua, C K, Leong, K F and Lim CS, *Rapid Prototyping: Principles and Applications in Manufacturing*, World Scientific, 2003.
3. Gibson, I., Rosen, D.W. and Stucker, B., *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, New York, 2010.
4. Raja, V. and Fernandes K.J., *Reverse Engineering – An Industrial Perspective*, Springer-Verlag London Ltd, 2008.

Course Description

Title: Special Purpose Vehicle **Code: ME353**

L-T-P Scheme: 3-0-0 **Credits: 3**

Prerequisite: Student must have already studied courses, "Engineering Thermodynamics, Manufacturing process, Kinematic of Machine, Dynamics of machine, Internal combustion engines and automobile engineering".

Objective:

1. To make aware of the basics of automobile history & its development and Bharat stage requirement in India.
2. To make aware of the role of the SPV in different industrial applications.
3. To learn the different types of special purpose vehicles for commercial and noncommercial applications.
4. To make able to do the analysis of the different common auxiliaries utilized in the SPVs.
5. To develop an understanding of environmental aspect associated with the utilization of internal combustion engine based SPVs.

Learning Outcomes :

Course Outcome	Description
CO1	Outline basis for the categorization of SPVs
CO2	Demonstrate working principals of the auxiliaries associated with the SPVs
CO3	Describe working principals of the Skidder, skipper, loader
CO4	Demonstrate and understand different auxiliary associated with the cooling and lubrication systems
CO5	Develop skill for the performance analysis of CI and SI Engines
CO6	Describe power assisted mechanisms used in SPVs

COURSE CONTENT

Unit-01: Classification of Special Purpose Vehicles: based on applications, wheel types & truck type. Study of working principles & design considerations: of different systems involved like power system, transmission, final drive, lubrication, electrical, braking, steering, pneumatic & hydraulic control circuits.

Unit-02: Constructional & working features: of different types of earth moving machinery such as Tippers, shovels, loaders, Excavators, Dumpers, Dozers, Fork Lift truck, Road rollers. Study of instrumentation applied to special purpose vehicles/machines.

Unit-03: Farm Tractor: Layout, Load distribution, Engine, Transmission & Drive line, Steering, Braking system, Wheels & Tyres, Hydraulic system, Auxiliary Systems, Draw bar, PTO Shaft. Different types of Implements, accessories and attachments. Tractor trolley.

Unit-04: Mobile Cranes: Basic characteristics of truck cranes, stability & design features, control systems & safety devices.

Unit-05: Tracked Vehicles, Articulated Vehicles, Multi-axle Vehicles, fifth wheel mechanism. Semi trailer & Prime mover brakes & electrical systems. Dead Axles. Special Purpose Electric Vehicles, Solar Vehicles and Hybrid Vehicles. Types, architecture and parameters of design considerations

Teaching Methodology:

This is introduced to make the student capable of utilizing skills developed as an outcome from their above-mentioned pre-requisite subjects, various constructional parameters of the child parts and their requirement. Course contain deals within this Special purpose vehicle subject is categorized in five different. Different adequate laboratories viz. Automobile Engineering, Internal combustion Engine, fluid machinery will helps student to examine the performance of different auxiliaries of the SPVs.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1, & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides of the special purpose vehicle subject (will be added from time to time): Digital copy will be available on the JUET server.

REFERENCE BOOKS:

1. Obert E.F., Internal Combustion Engines & Air pollution, Hopper & Row Pub., New York.
2. Heywood J. B., Internal Combustion Engines Fundamentals, McGraw Hill, New York

Web References:

1. https://www.saeindia.org
2. http://www.oica.net
3. https://uia.org

Journals References:

1. https://www.sciencedirect.com/journal/transportation-research-part-a-policy-and-practice
2. https://www.sciencedirect.com/journal/journal-of-cleaner-production
3. https://www.sciencedirect.com/journal/advances-in-engineering-software

Course Description

Title: Transducers Engineering **Code: EC334**

L-T Scheme: 3-0-0 **Credits: 3**

Prerequisite: Not Applicable

Objectives:

1. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
2. To familiarize with the selection criterion and installation process of transducers.
3. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various types of transducers concerning their application in the industry.
CO2	Describe the operating principle of various types of the transducer.
CO3	Develop skills to select a transducer for a specific measurement requirement.
CO4	Identify and use various transducers and signal conditioning circuits used in the measurement process.
CO5	Analyze the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit 1: Transducer Fundamentals: Basic concept of Sensors and transducer, their comparisons, Classification of Transducer, Working of transducers used for measurement of Displacement- resistive, inductive and capacitive method, Linear and Angular Velocity moving coil and moving magnet method, various tachometers and stroboscope, Acceleration- seismic and peizo electric accelerometer, Working principle of Capacitive Transducer, Piezo-Electric Transducer, and LVDT.

Unit 2: Strain and Temperature Measurement: Measurement Strain Gauges- strain measurement technique, resistance strain gauge and its types, Signal conditioning of strain gauges, Transducers for Temperature Measurement- non- electrical and electrical method, Bimetallic Thermometer, Resistance Thermometer like RTD, Thermistor and Thermocouple, Radiation and Optical Pyrometer.

Unit 3: Pressure Measurement: Transducers for Measurement of Pressure: - Manometers types (like Single column, inclined, U-tube), Mechanical Types (Bourdon, bellows and diaphragm), Elastic Types transducers, Low Pressure measurement gauges (Ionization, McLeod etc.).

Unit 4: Flow Measurement: Transducers for Measurement of Flow: - Types of flow meters, Theory of variable head constant area meter and its types, theory of constant head variable area meter and its types, theory of variable head variable area meter and its types, Special flow meters- Electromagnetic, Hot wire Anemometer, Turbine meter and Ultrasonic flow meter.

Unit 5: Miscellaneous Measurement and Smart Sensor: Transducer for Level Measurement:- direct and indirect method, resistive method, Ultrasonic, Capacitive and Gamma Ray level Gauges. Measurement of Humidity and Moisture- basic definitions, psychometric method, Smart sensors - Fibre optic sensors, MEMS – Nano sensors, proximity sensor.

Teaching Methodology:

This course is introduced to familiarize the student with the various transducers used in the automation industry. Starting from the basic concepts, the student will gradually develop an understanding of practical setups used in the industry. The entire course is broken down into five units, such that each unit covers the use of transducer for a particular application. This theory course is well complemented by a laboratory course under the name Transducer Engineering Lab in the same semester that helps a student learn with hands-on experience.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on transducers (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[2] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[3] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[1] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[2] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[3] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[4] Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 2005.

Web References:

[1] https://nptel.ac.in/courses/108/108/108108147/

[2] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[3] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[1] Sensors and Actuators A: Physical (Elsevier)

[2] Journal of Sensors (Hindawi)

Course Description

Title: Transducer Engineering Laboratory **Code: EC401**

L-T-P scheme: 0-0-2 **Credit: 1**

Objectives:

1. To understand the principle of operation and the important characteristics of transducers commonly used in industry.
2. To familiarize with the selection criterion and installation process of transducers.
3. To design the appropriate signal conditioning circuit for specific measurement requirement.

Learning Outcomes: In reference to Transducer Engineering (18B11EC914), the students will be able to:

Course Outcome	Description
CO1	Outline various types of transducers used in the automation industry.
CO2	Describe the constructional details and working of various types of the transducer.
CO3	Develop a signal conditioning circuit to interface the transducer to the digital systems.
CO4	Identify and select a transducer for a specific measurement requirement.
CO5	Apply the analytical techniques to evaluate the performance of the transducer.
CO6	Demonstrate the application of various transducers.

Course Content:

Unit 1: Lab exercise based on introduction to sensors and transducers

Unit 2: Lab exercise based on working of various transducers

Unit 3: Lab exercise based on implementation of interfacing circuits to convert non-electrical signals to electrical signals.

Unit 4: Lab exercise based on measurement of physical parameters such as temperature, force, flow-rate etc.

Unit 5: Lab exercise based on the determination of electrical properties such as resistance, inductance, capacitance

Teaching Methodology:

This course is introduced to help the students to familiarize with the devices and methods used for automatic measurement. In this course, the mixed technique of interactive discussion, regular assignments will be used. In the discussion the fundamental theoretical concepts will be introduced and demonstrated through examples. Discussion will be implemented in laboratory by using the practical setups.

Evaluation Scheme:

Exams		Marks	Coverage
P-1		15 Marks	Based on Lab Exercises: 1-5
P-2		15 Marks	Based on Lab Exercises: 6-11
Day-to-Day Work	Viva	20 Marks	70 Marks
	Demonstration	20 Marks	
	Lab Record	15 Marks	
	Attendance & Discipline	15 Marks	
Total		**100 Marks**	

Learning Resources:

Study material of Measurement & Instrumentation Lab (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] A.K.Sawhney & Puneet Sawhney, A Course in Mechanical Measurements and Instrumentation, 12/e, Dhanpat Rai & Co. (P) Ltd.,2004

[2] B.C.Nakra & K.K.Chaudhary,Instrumentation Measurement And Analysis, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1996

[3] D.Patranabis, Principles of Industrial Instrumentation, 2/e, Tata McGraw-Hill Publishing Company Ltd, New Delhi.,1998

Reference Books/Materials:

[1] James W. Dally, William F. Riley & Kenneth G.McConnell, Instrumentation for Engineering Measurements,2/e,Wiley Student Edition, John Wiley & Sons,INC,2003.

[2] John P.Bentley, Principles of Measurement Systems, Low Price Edition, Pearson Education Asia,2000

[3] Dr.D.S.Kumar, Mechanical Measurements and Control, 3/e, Reprint-2004, Metropolitan Book Co. Private Ltd.,2004

[4] Liptak, B.G., "Instrumentation Engineers Handbook (Measurement)", CRC Press, 2005.

Web References:

[4] https://nptel.ac.in/courses/108/108/108108147/

[5] https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112104250/lec21.pdf

[6] https://www.electronics-tutorials.ws/io/io_1.html

Journals References:

[1] Sensors and Actuators A: Physical (Elsevier)

[2] Journal of Sensors (Hindawi)

Course Description

Title: Digital Control System **Code: EC335**

L-T-P Scheme: 3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Control Systems*".

Objective:

1. To familiarize the student with the working of automation systems.
2. To develop an ability to design a computer-aided control system with given requirements.

Learning Outcomes:

Course Outcome	Description
CO1	Outline various digital control systems and their application.
CO2	Describe the element and operation of a digital control system.
CO3	Develop the architecture of an automation system based on the specified requirements.
CO4	Identify the hardware and software components of a computer-aided control system.
CO5	Application of digital control systems on a given assignment/ project.
CO6	Demonstration and deployment of basic software modules of a digital control system.

Course Content:

Unit 1: Introduction to Digital Control: Review of conventional control system. Manual and automatic control schemes. Model-based and model-less control. Need of automatic control, Advantages, Limitations, Applications.

Unit 2: Programmable Logic Controller: History of programmable logic controller (PLC). Architecture of PLC. Elements of PLC, CPU, IO Modules, Power supply and Communication Modules, Input Output Devices, Interfacing of Field Devices.

Unit 3: Distributed Control Systems: Basics of Distributed Control Systems (DCS). Architecture and Working. Components of DCS, Field Instruments and Interfacing Circuits, Communication Protocols. Control of Field Instruments using Relay Devices.

Unit 4: Supervisory Control and Data Acquisition (SCADA): Introduction to SCADA. Fundamental Principle of Modern SCADA Systems. SCADA Hardware and Software. Remote Terminal Units (RTU). Master Station. Interfacing between SCADA and PLC.

Unit 5: Design of Industrial Automation Setup: Requirement gathering, System layout, Identification of Modules, Hardware Implementation, Software design. Case Study of Industrial Automation in Food Processing and Manufacturing Industry.

Teaching Methodology:

This course is introduced to help students transition from a simple electrical and electronics engineering concepts to applications of digital control system. Starting with the understanding of continuous systems, the student will be able to understand computer-aided control and other aspects of system analysis. The entire course is broken down into five separate units to develop an understanding of various aspects of automation. Each section includes multiple technologies to help a student gain more experience as an electronic control system designer.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 to Unit-6 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Lecture notes/slides on Digital Control System (will be added from time to time): Digital copy will be available on the JUET server.

Text Books:

[1] K.S. Manoj, Industrial Automation with SCADA: Concepts, Communications and Security, Notion Press, 1/e, Indian Edition, 2019.

[2] T.R. Kurfess, Robotics and Automation Handbook, CRC Press, 2/e, Indian Edition, 2004.

Reference Books/Material:

[1] G. F. Franklin, J. D.Powell and M. L. Workman, Digital Control of Dynamic Systems, Addison Wesley, 1998,Pearson Education,Asia, 3/e, 2000.

[2] K. J.Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.

Web References:

[1] https://nptel.ac.in/courses/108/105/108105088/

[2] https://www.eolss.net/

Journals References:

[1] Science direct journal of digital control system

[2] IRE Transactions on Industrial Electronics

Course Description

Title: Computer Integrated Manufacturing (CIM) **Code: ME355**

L-T-P Scheme: 3-0-0 **Credits: 3**

Objectives:

- This course introduces students with computer assisted modern manufacturing technologies.
- The topics covered in this course include basics of automation, NC programming (manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics.
- The objective of this course is to make students learn the important theoretical concepts, and the state-of-the-art technological developments in the area of modern manufacturing.

Learning Outcome:

Course Outcome	Description
CO1	Outline basic concepts related to CIM like types of production, plant layout, sequencing and scheduling, group technology, types of automation and FMS.
CO2	Describe NC, CNC and DNC, types and components of FMS, part classification and coding schemes, computer aided process planning (CAPP) and Automated inspection.
CO3	Develop ability to write CNC part programs, formation of part families, pick and place programs for robot and automated inspection through CMM.
CO4	Identify the sequence of operation, generate process plan and simulate the FMS operation in off-line mode.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in CIM lab of the department.
CO6	Demonstrate ability to work in a flexible manufacturing system in an organization.

COURSE CONTENT

Introduction: Automation, Need for Automation, Types of automation systems, Automation strategies, levels of automation, Introduction to NC, CNC and DNC and Computer integrated manufacturing, CIM wheel, components of CIM

Part programming: Introduction, NC coordinate system, fixed and floating zero machines, NC motion control systems, part programming methods, Manual part programming for milling and lathe using G and M codes, various canned cycles

Group Technology: part families, part classification and coding, production flow analysis, composite part concept, benefits of GT.

Flexible Manufacturing System: Definition of FMS, components of FMS, types of flexibilities, classification of FMS, primary and secondary material handling systems, FMS layout configurations, computer control system, FMS applications and benefits.

Automated Material Handling and AS/RS: Introduction, types of material handling equipment, automated guided vehicle system (AGVs), applications, vehicle guidance and routing, traffic control and safety system management, Basic components of AS/RS, types of AS/RS, AS/RS controls, special features

Robotics: Definition, robot anatomy and related attributes, robot configuration, work volume, types of control systems, end effectors, industrial applications of robot, introduction to robot programming.

Automated Inspection & Testing: Automated inspection principles, off-line and on-line inspection, contact and noncontact inspection techniques, Co-ordinate measuring machine (CMM): Introduction and types of CMM.

Manufacturing Support System: Product design and CAD, concurrent engineering and Computer aided process planning (CAPP).

Teaching Methodology:

This course is introduced to help students learn and understand the computer assisted manufacturing processes. Then they will be taught about CNC machines and their part programming. Finally, they will be made aware about FMS and CIM systems. This theory course is well complemented by a laboratory course under the name CIM Lab that helps students learn with hand-on experience.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1, Unit-2 and Unit-3
Test-2	25 Marks	Based on Unit-3, Unit-4, Unit-5 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-6, Unit-7, Unit-8 and and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

TEXT BOOK:

2. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
3. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

REFERENCES:

1. Parrish D. J, "Flexible manufacturing", Butterworth – Heinemann Ltd, 1990
2. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi
3. Jha, N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc.

Course Description

Title: CIM Lab **Code : ME402**

L-T-P scheme: 0-0-2 **Credit: 1**

Scope and Objectives

- This course is designed to provide practical experience to the students with an opportunity of hands-on training on modern CNC machines and CIM system.
- The topics covered in this course include the basics of automation, NC programming (Manual and APT), concepts of group technology, Flexible Manufacturing system, CIM and robotics etc.
- The objective of this course is to expose the students to practical aspects of automation and the state-of-the-art technological developments in the area of modern manufacturing.

LEARNING OUTCOME:

Course Outcome	Description
CO1	Outline basic concepts related to CIM like types of production, plant layout, sequencing and scheduling, group technology, types of automation and FMS.
CO2	Describe NC, CNC and DNC, types and components of FMS, part classification and coding schemes, computer aided process planning (CAPP) and Automated inspection.
CO3	Develop ability to write CNC part programs, formation of part families, pick and place programs for robot and automated inspection through CMM.
CO4	Identify the sequence of operation, generate process plan and simulate the FMS operation in off-line mode.
CO5	Apply acquired knowledge to perform machining, inspection and assembly operations on Flexible manufacturing system available in CIM lab of the department.
CO6	Demonstrate ability to work in a flexible manufacturing system in an organization.

COURSE CONTENT

XL Turn Machine

1. Write a manual part program for Linear and Circular Contour (G01, G02, and G03) operation for the component.
2. Write a manual part program for Box Facing (G94) operation for the component.
3. Write a manual part program for Multiple Facing (G72) operation for the component.
4. Write a manual part program for Multiple Turning operation with G71 Cycle for the component.
5. Write a manual part program for Peck Drilling operation with G74 Cycle for the component.
6. Write a manual part program for Turning and Parting OFF operation through subroutines for the component.

XL Mill Machine

7. Write a manual part program for Contouring (G01, G02, and G03) operation (Linear & Circular Interpolation) for the component.
8. Write a manual part program for Contouring (G40, G41) operation with Left cutter diameter compensation for the component.
9. Write a manual part program for Contouring (M98, M99) operation through subprogram for the component.
10. Write a manual part program for Mirroring (M70, M71, M80, and M81) operation for the component.
11. Write a manual part program for Drilling (G73, G83, G98, and G99) operation for the component.
12. Write a manual part program for Pocketing (G170, G171) operation for the component.

5-axis and 6-axis Robot

13. Write a program for pick and place operation for 5-axis robot
14. Write a program for continuous welding operation for 6-axis robot

Coordinate Measuring machine (CMM)

15. Write a program for automatic measurement of various dimensions such as OD, ID, thickness etc. of a part.

Complete CIM System

16. Demonstration and study of CIM system Off-line manual mode.
17. Demonstration and study of CIM system on-line automatic mode

Teaching Methodology:

This course is introduced to help students learn and understand the fundamentals and hands on knowledge of computer integrated manufacturing. Students will make and simulate part programs for CNC Lathe and Milling machines and perform machining on these machines. They will also do Robot programming. Finally, they will be performing automatic operations on FMS and CIM systems. This lab course is well complemented by a theory course under the name Computer Integrated Manufacturing (CIM) that helps students learn with hand-on experience.

Evaluation Scheme:

<table>
<tr><th>Exams</th><th>Marks</th><th>Coverage</th></tr>
<tr><td>P-1</td><td>15 Marks</td><td>Based on Lab Exercises: 1-7</td></tr>
<tr><td>P-2</td><td>15 Marks</td><td>Based on Lab Exercises: 8-14</td></tr>
<tr><td rowspan="4">Day-to-Day Work</td><td>Viva</td><td rowspan="4">70 Marks</td></tr>
<tr><td>Demonstration</td></tr>
<tr><td>Lab Record</td></tr>
<tr><td>Attendance & Discipline</td></tr>
<tr><td>Total</td><td colspan="2">100 Marks</td></tr>
</table>

TEXT BOOK:

1. Groover M. P., Automation, Production Systems And Computer-integrated Manufacturing, PHI.
4. CNC XLTURN Manual by MTAB, Chennai
5. CNC XLMILL Manual by MTAB, Chennai
6. Miller R. K., FMS/CIM Systems Integrated Handbook, Prentice Hall

REFERENCES:

6. Parrish D. J, “Flexible manufacturing”, Butterworth – Heinemann Ltd, 1990
7. Rao, P.N., CAD / CAM Principles and Applications, McGraw Hill Publishers, New Delhi
8. Jha, N. K., Handbook of Flexible Manufacturing Systems, Academic Press Inc.

Course Description

Title: Vehicle Dynamics **Code: ME354**

L-T-P scheme:3-0-0 **Credit: 3**

Prerequisite: Students must have already studied course, "*Automobile engineering*".

Objective:

To provide the knowledge of vehicle interactions, longitudinal dynamics: Steady state functions, Functions over longer event, Functions over shorter events, Lateral dynamics: Low speed maneuverability, Steady state cornering at high speed, Vertical dynamics.

Learning Outcomes:

Course Outcome	Description
CO1	Outline basic principles of accelerating or braking a car and influence of driving resistances on vehicle dynamics.
CO2	Describe the discrepancy between demands and limits of power train.
CO3	Develop correlation between braking, wheel load and recovery of energy.
CO4	Identify the necessity of gears, clutches, different kinds of suspensions, springs and dampers.
CO5	Understand the single track model, slip angle and cornering forces
CO6	Demonstrate the conflict between driving safety and comfort.

Course Content:

Unit-1: Longitudinal dynamic aspects of vehicles. Clear and brief: acceleration and braking. Driving resistances and slip

Unit-2: Demand of power and limits of a car, Elements involved when a car drives on a bumpy or rough street.

Unit-3: Survey of suspensions, springs and dampers. Simple single-track model, describe the slip angle of a wheel, cornering forces, lateral dynamics.

Unit-4: Dependency between longitudinal and lateral forces using Kamm's circle, Krempel's diagram,steady state cornering of the car.

Unit-5:Conflict between driving safety and comfort**.**

Teaching Methodology:

The development of vehicle dynamics has moved toward modeling, analysis, and optimization of multi-body dynamics supported by some compliant members. Therefore, merging dynamics with optimization theory was an expected development. The fast-growing capability of accurate positioning, sensing, and calculations, along with intelligent computer programming are the other important developments in vehicle dynamics.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1& Unit-2
Test-2	25 Marks	Based on Unit-3& Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 and around 30% from coverage of Test-1 & Test-2.
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Course-related resources will be provided on JUET server. This can include eBook, lecture material, supplementary course notes.

Text Book:

[1] Fundamentals of Vehicle Dynamics by T. Gillespie

[2] Vehicle Dynamics and Control by Rajesh Rajamani

Reference Books/Material:

[1] Tyre and Vehicle Dynamics by Hans B Pacejka

[2] Vehicle Dynamics, Theory and Applications by Reza N Jazar

Web References:

[1]https://docs.google.com/file/d/0B8Gz6W5GXwyoYzQ0ZjVlNTktYWQyYi00NThiLWJlM2YtNTcxYmI2OTQ0ODAz/edit

[2] https://www.dropbox.com/sh/es39r0uylix1ryo/AADHGK5_IVLIY7QSYIQviyQ6a/Automotive%20related%20books?dl=0&subfolder_nav_tracking=1

Journals References:

[1] Journal of Automobile Engineering: SAGE

Course Description

Title: Automated Guided Vehicles **Code: ME357**

L-T-P Scheme: 3-0-0 **Credits: 3**

Prerequisite: Student must have already studied courses, "Engineering Thermodynamics, Manufacturing process, Kinematic of machine, Dynamics of machine, Internal combustion engines, hybrid Engines and automobile engineering, microprocessor and control system, Image processing, radar technology in brief".

Objective:

6. To make aware of the basics of future of the automobile industry.
7. To make aware of the role of the Automated guided vehicles (AGV) for different applications.
8. To learn the different types of special purpose AGVs for commercial and noncommercial applications .
9. To make able to do the analysis of the different common auxiliaries utilized in the AGVs.
10. To develop an understanding of environmental aspect associated with the utilization of internal combustion engine based AGVs.

11. Learning Outcomes :

Course Outcome	Description
CO1	Outline basis for the categorization of AGVs
CO2	Demonstrate working principals of the auxiliaries associated with the AGVs
CO3	Describe working principals of the Skidder, skipper, loader and SP-AGVs
CO4	Demonstrate and understand different auxiliary associated AGVs
CO5	Develop skill for the performance analysis of AGVs
CO6	Describe power assisted mechanisms used in AGVs

COURSE CONTENT

Automated guided Vehicles (Credits: 3)

Unit 1: Basic components of Automated guided vehicle (AGV), electric, pneumatic/ hydraulic systems for control.

Unit 2: Automated guided vehicle (AGV) systems design. System performance analysis, system stability assessment.

Unit 3: Analogue and digital control systems and their applications. Design principle of guidance path system.

Unit 4: Introduction and principle of floor control and traffic management system. Industrial Applications of Automated guided vehicle (AGV).

Teaching Methodology:

This is introduced to make the student capable of utilizing skills developed as an outcome from their above-mentioned pre-requisite subjects, various constructional parameters of the child parts and their requirement. Course contain deals within this Automated guided vehicle subject is categorized in four different. Different adequate laboratories viz. Automobile Engineering, Internal combustion Engine, fluid machinery and COEs/RC will helps student to examine the performance of different auxiliaries of the AGVs.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, & Unit-2
Test-2	25 Marks	Based on Unit-3 & Unit-4 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-5 around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides of the special purpose vehicle subject (will be added from time to time): Digital copy will be available on the JUET server.

REFERENCE BOOKS:

- Robot Operating System for Absolute Beginners: Robotics Programming Made Easyby Lentin Joseph
- Robot Operating System (ROS): The Complete Reference (Volume 1) by Anis Koubaa
- Robot Operating System (ROS): The Complete Reference (Volume 2) by Anis Koubaa
- Robot Operating System (ROS): The Complete Reference (Volume 3) by Anis Koubaa
- Robotics, Vision and Control: Fundamental Algorithms In MATLAB® Second, Completely by Peter Corke

Web References:

4. https://www.saeindia.org
5. http://www.oica.net
6. https://uia.org

Journals References:

- https://www.sciencedirect.com/journal/advances-in-engineering-software

Course Description

Title: Control of Mechanical System **Code: ME356**

L-T-P Scheme:3-0-0 **Credit: 3**

Prerequisite: Students must have already studied courses, "*Engineering Mechanics and Theory of Machine*".

Objective:

1. To understand different controls of mechanical systems.
2. To design mechanical control systems as per the requirements.

Learning Outcomes:

Course outcome	Description
CO1	Outline various mechanical systems, control of mechanical systems and control modes
CO2	Describe various mechanical systems and control systems
CO3	Develop the knowledge of modelling, analyzing and designing various control for mechanical systems
CO4	Identify and use the proper mechanical system and their control required to be implemented
CO5	Apply the knowledge of control of mechanical systems to implement in the required field
CO6	Demonstrate the practical exposure of various mechanical systems are their control

Course Content:

Unit 1: Introduction: Human-machine interaction and the need for control of mechanical systems, different mechanical systems

Unit 2: Mathematical modelling of physical systems: Mechanical, electrical, fluid, and thermal building blocks, rotational-translational, electro-mechanical and hydraulic-mechanical system models, modelling of dynamic systems: first and second order systems, system transfer functions.

Unit 3: Control system components, stability and algebraic criteria, transient response analysis, stability, and damping

Unit 4: Frequency domain techniques for analysis and design of dynamic systems: root locus and frequency response analysis

Unit 5: PID controls, analysis and design of control systems, advanced control topics

Teaching Methodology: The fundamentals of mechanical systems are to be briefly discussed with their requirements. Mathematical modelling of all the mechanical systemsare to be completed. The modelling of dynamic modelsare to be completed for first and second-order system models and to find the transfer functions of the system models. After that, the introduction to the control system is to be discussed along with the components of the control system. The stability of the control systems are to be analysed. The transient analysis of the control systems are to be discussed, along with the concepts of damping the system. Then the mechanical control systems are to be analysed and designed using root locus and frequency response analysis. At last, the various modes of control are to be discussed along with examples, including PID controls.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1, and Unit-2
Test-2	25 Marks	Based on Unit-2, Unit-3& Unit-4 and around 20% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4and Unit-5 and around 14.3% from coverage of Test-1 and Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and assignments on Control of mechanical system(will be added from time to time): Digital copy will be available on the JUET server.

Textbook:

1. Mechatronics by W. Bolton
2. Control systems engineering by Norman S. Nise

Reference Books/Material:

1. Theory and design for mechanical measurements by Richard S. Figliola and Donald E. Beasley

Web References:

1. https://onlinecourses.nptel.ac.in/noc22_me96/preview

Journals References:

1. Transaction On Control and Mechanical Systems
2. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering