COURSE TITLE	**MEASUREMENT SYSTEMS AND SENSORS**
COURSE CODE	**01MR0401**
COURSE CREDITS	**4**

Objective:

1 The course aims to familiarize students with the key elements and techniques of mechanical systems for industrial automation, impart both theoretical and practical knowledge of measurement system design, and provide insights into the principles of sensors along with their interfacing with Data Acquisition System (DAQ).

Course Outcomes: After completion of this course, student will be able to:

1 Apply measurement principles to select appropriate instruments.
2 Apply metrology tools to perform dimensional measurements.
3 Analyze performance of basic sensors for engineering applications.
4 Analyze suitability of advanced sensors for automated systems..
5 Evaluate integrated multivariable sensor systems with signal conditioning.

Pre-requisite of course: Nil

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Measurement System** Introduction to measurement, Standards of Measurement, Modes of Measurement, Generalized Measurement System, Errors in measurement, Sources of errors, Specifications of Instrument, Static characteristics (accuracy, precision, linearity, hysteresis, drift), Dynamic characteristics (speed of response, lag, fidelity, dynamic error)	7
2	**Metrology** Linear and angular measurement devices, Gauge blocks, Measurement of geometric characteristics (straightness, flatness, roundness, Circularity), Optical Projectors, Tool Maker's Microscope, Interferometers, Comparators, Measurement of Screw Threads and Gears, Surface Texture Measurement, Laser scanning, CMM	8

Contents : Unit	Topics	Contact Hours
3	**Basic Sensors** Position and Speed Measurement, Potentiometer, Temperature Measurement, Bimetallic Strip Thermometer, Electrical Resistance Thermometer (RTD), Thermocouple, LVDT, Digital Optical Encoder, IR sensors, Ultrasonic sensors, Stress and Strain Measurement, Measuring Resistance Changes with a Wheatstone Bridge, Measuring Different States of Stress with Strain Gauges	7
4	**Advanced Sensors** Force Measurement with Load Cells, Pressure and Flow Measurement, Capacitive Sensors, Fiber Optic Sensors, Semiconductor Sensors, Microelectromechanical Devices (IMU, Gyroscope), Vision sensors, Tactile sensors, Light detection and ranging sensor (LiDAR)	9
5	**Data Acquisition** Introduction to Data Acquisition, Quantizing Theory, Analog-to-Digital Conversion (ADC), Digital-to-Analog Conversion (DAC), Signal Conditioning, Computer-Based Instrumentation Systems, Data Recording and Logging, The Intelligent Multivariable Measurement System, IoT-DAQ, Cloud logging, AI/ML analytics	11
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment 1** To apply Vernier, micrometer and height gauge for dimension measurement of mechanical components.	2
2	**Experiment 2** To apply angular measurement techniques using a bevel protractor.	2
3	**Experiment 3** To measure gear tooth elements using a gear tooth vernier caliper..	2
4	**Experiment 4** To apply digital, I/O operations in Arduino for developing and testing an LED blinking circuit.	2
5	**Experiment 5** To acquire and analyze temperature data using Arduino-based sensors and evaluate sensor response characteristics.	2
6	**Experiment 6** To apply ultrasonic sensing for distance measurement and analyze measurement accuracy.	2
7	**Experiment 7** To measure weight using Load cell (strain gauge) using arduino microcontroller.	2
8	**Experiment 8** To measure strain of beam using strain gauge and arduino microcontroller.	2

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
9	**Experiment 9** To acquire vibration signals using Arduino, analyze frequency response through FFT, and evaluate dominant vibration modes.	2
10	**Experiment 10** To measure acceleration using a MEMS accelerometer.	2
11	**Experiment 11** To measure magnetic field and rotational speed using a Hall sensor and evaluate its suitability for motion sensing..	2
12	**Experiment 12** To apply a rotary encoder for angular displacement and direction measurement and analyze encoder resolution and accuracy.	2
13	**Experiment 13** To detect objects using proximity sensors and evaluate detection range.	2
Total Hours		**26**

Textbook :

1 Metrology & Measurement, A. K. Bewoor and V. A. Kulkarni, McGraw-Hill Education, 2009

2 Mechanical Measurements, S. P. Venkateshan, Oxford University Press, 2015

3 Mechanical Measurements and Instrumentation, R. K. Jain, Khanna Publishers, 2013

References:

1 Engineering Metrology and Measurements, Engineering Metrology and Measurements, N. V. Raghavendra and L. Krishnamurthy, Oxford University Press, 2013

2 Engineering Metrology, Engineering Metrology, R. K. Jain, Khanna Publishers, 2014

3 Transducers and Instrumentation, Transducers and Instrumentation, D. V. S. Murthy, PHI Learning, 2003

4 Principles of Measurement Systems, Principles of Measurement Systems, E. O. Doebelin and D. Manik, McGraw-Hill Education, 2011

5 Measurement Systems: Application and Design, Measurement Systems: Application and Design, E. O. Doebelin, McGraw-Hill, 2003

6 Data Acquisition for Instrumentation and Control Systems, Data Acquisition for Instrumentation and Control Systems, N. E. Battikha, Elsevier, 2003

7 PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, K. James, Oxford, U.K.: Newnes, 2000

8 Principles of Measurement Systems, Principles of Measurement Systems, J. P. Bentley, Pearson Prentice Hall, 2008

9 Mechatronics: Principles and Applications, Mechatronics: Principles and Applications, C. Onwubolu and G. C. Fantuzzi, Butterworth-Heinemann, 2020

References:

10 Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, W. Bolton, Pearson Education, 2018

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Higher order Thinking / Creative**
0.00	0.00	40.00	40.00	20.00	0.00

Instructional Method:

1 Power point presentation and videos

Supplementary Resources:

1 Mechanical Measurement and Metrology - https://nptel.ac.in/courses/112106138
2 Sensors and Actuators - https://nptel.ac.in/courses/108108147
3 Mechatronics and Manufacturing Automation - https://nptel.ac.in/courses/112103174
4 Arduino for Beginners - Sensors & Data Logging - https://www.udemy.com/course/arduino-for-beginners-complete-course
5 Automotive Engine Sensors Intro, Operation & Diagnostic - https://www.udemy.com/course/automotive-engine-sensors-intro-operation-diagnostic
6 Arduino IDE - https://www.arduino.cc/en/software (For interfacing all basic and advanced sensors)
7 NI LabVIEW (Community Edition) - https://www.ni.com/en-us/shop/labview.html (For DAQ, signal conditioning, sensor integration)
8 MATLAB/Simulink (Student Version) - https://in.mathworks.com/academia/student_version.html (For signal analysis, FFT, sensor simulation)
9 Sigview Signal Analysis Software - https://sigview.com/ (For vibration and frequency response analysis)
10 Proteus Design Suite (Student Version) - https://www.labcenter.com/downloads/ (For virtual circuit simulation of sensors/DAQ)