Gyanmanjari Innovative University

Syllabus
Gyanmanjari Institute of Technology
Semester-3 (B. Tech)

Subject: Measurements and Instrumentation - BET2EE13304

Type of course: Professional Core

Prerequisite: Basic Electrical & Electronics Engineering.

Rationale:

This course provides fundamental knowledge of electrical and electronic measurement techniques, measuring instruments, sensors, and instrumentation systems used in engineering applications. It helps students understand the principles of measurement, signal conditioning, data acquisition, and performance analysis of instruments through theoretical concepts and practical experiments. The course develops skills in measurement, monitoring, troubleshooting, and analysis required for industrial automation, process control, power systems, and modern electronic instrumentation applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
2	0	4	4	100	50	150

Legends: CI-Classroom Instructions; T-Tutorial; P -Practical; C –Credit; ESE -End Semester Examination; MSE-Mid Semester Examination; V–Viva; CA-Continuous Assessment; ALA-Active Learning Activities.

Course Content:

Sr. No.	Course Content	Hrs.	% Weightage
1	**Fundamentals of Instrumentation and Measurement** ***Theory Topics:*** Fundamentals of Instrumentation and Measurement covering measurement systems, units and standards, static and dynamic characteristics of instruments, types of errors and their analysis, analog and digital measuring instruments, multimeters, CRO and DSO basics, measurement of electrical quantities such as voltage, current, resistance and power, transducers and sensors, signal conditioning techniques, and basics of data acquisition systems. ***Practical:*** 1. Measurement of voltage, current and resistance using analog and digital multimeters.	15	20 %

2. Verification and comparison of moving coil and moving iron instruments.
3. Measurement of power using voltmeter and ammeter method.
4. Study of waveform measurement using CRO or DSO.
5. Measurement of frequency and phase difference using CRO.
6. Study and calibration of basic transducers and sensors.
7. Verification of signal conditioning circuits using an operational amplifier.
8. Measurement of temperature using temperature sensors.

Evaluation Method:

Sr. No.	Evaluation Method	SEE (Marks)	CCE (Marks)
1.	**Measurement using Analog and Digital Instruments:** Measure voltage, current and resistance using suitable measuring instruments, record observations, perform error analysis, and explain the working principles of the instruments used	20	–
2.	**Comparative Analysis of Analog and Digital Instruments:** Perform measurement of voltage, current, and resistance using analog and digital multimeters and prepare a comparative analysis report based on accuracy, range, sensitivity, and ease of operation.	–	10
	Total	20	10

Examination Style:

Measurement using Analog and Digital Instruments (20 Marks)

Students shall perform measurements of electrical quantities such as voltage, current, and resistance using both analog and digital measuring instruments. The activity shall include identification of instrument specifications, proper selection of measuring range, correct connection of instruments, and recording of observations for different test conditions. Students shall compare the measured values obtained from analog and digital instruments and perform error analysis wherever applicable. The assessment shall also evaluate the student's ability to interpret readings, follow standard measurement procedures, and explain the operating principles of the instruments used. Students may be asked to justify the selection of instruments for a given measurement task and discuss factors affecting measurement accuracy. The completed observation sheet, calculations, and analysis shall be submitted during the

	examination. **Comparative Analysis of Analog and Digital Instruments (10 Marks)** Students shall conduct a comparative study of analog and digital measuring instruments by performing measurements of voltage, current, and resistance. Based on the experimental observations, students shall prepare a report comparing the instruments with respect to accuracy, range, sensitivity, resolution, response time, and ease of operation. The report shall include measurement data, calculations, graphical representation (if applicable), observations, advantages and limitations of each instrument, and conclusions. The activity aims to develop analytical skills and understanding of the practical applications of different measurement instruments used in engineering systems.		
2	**Electrical and Electronic Measurements** ***Theory Topics:*** Electrical and Electronic Measurements covering measurement of voltage, current, resistance, power and energy, bridges for electrical measurements, AC and DC measuring instruments, wattmeter and energy meter, measurement of frequency and phase angle, electronic voltmeters, digital instruments, signal generators, and basics of calibration techniques. ***Practical:*** 9. Measurement of unknown resistance using Wheatstone bridge. 10. Measurement of inductance and capacitance using AC bridges. 11. Measurement of power using wattmeter. 12. Study and testing of single-phase energy meter. 13. Measurement of frequency and phase difference using CRO. 14. Verification of electronic voltmeter characteristics. 15. Study of function generator and signal generator. 16. Calibration of measuring instruments using standard references. 17. Measurement of electrical quantities using digital instruments **Evaluation Method:** **Sr. No. / Evaluation Methods / SEE / CCE**	08	20%

	1	**Bridge Circuit Measurements:** Perform measurement using Wheatstone bridge or AC bridge circuits, record observations, analyze measured values with necessary calculations, and explain the measurement techniques and instruments used	20	–		
	2	**Bridge Circuit Design and Error Analysis:** Design and demonstrate a bridge circuit for measurement of an unknown resistance and analyze the effect of measurement errors in the obtained readings.	–	10		
		Total	20	10		

Examination Style:

Bridge Circuit Measurements (20 Marks)
Students shall perform measurements using Wheatstone Bridge and/or AC Bridge circuits for the determination of unknown electrical parameters such as resistance, inductance, or capacitance. The activity shall include proper circuit setup, selection of suitable bridge components, balancing of the bridge circuit, and recording of observations. Students shall calculate the unknown parameter using standard bridge equations and verify the obtained results. The assessment shall evaluate the student's understanding of bridge balancing conditions, measurement principles, circuit operation, and practical implementation skills. Students shall also explain the instruments used, sources of error, and precautions required during the measurement process. The completed observation sheet, calculations, and analysis shall be submitted during the examination.

Bridge Circuit Design and Error Analysis (10 Marks)
Students shall design and demonstrate a bridge circuit for the measurement of an unknown resistance and analyze the effect of measurement errors on the obtained results. The activity shall include circuit design, component selection, preparation of circuit diagram, practical implementation or simulation, and measurement of the unknown resistance. Students shall investigate the influence of component tolerances, instrument accuracy, and balancing errors on the final measurement. The report shall include circuit design details, observations, calculations, error analysis, results, and conclusions. The activity aims to develop circuit design, analytical, and problem-solving skills in electrical measurements.

3	**Sensors and Transducers** ***Theory Topics:*** Sensors and Transducers covering classification of transducers, active	10	20%

and passive transducers, resistive, inductive and capacitive transducers, temperature sensors, pressure and displacement sensors, strain gauges, LVDT, piezoelectric and optical sensors, smart sensors, signal conditioning circuits, sensor calibration techniques, and industrial applications of sensors and transducers

Practical:

18. Study and calibration of temperature sensors.
19. Verification of characteristics of LVDT.
20. Measurement of displacement using LVDT.
21. Study of strain gauge and load cell characteristics.
22. Measurement using capacitive and inductive sensors.
23. Interfacing of sensors with signal conditioning circuits.
24. Study of pressure or proximity sensors.
25. Measurement and analysis using piezoelectric sensor.
26. Sensor interfacing using microcontroller or Arduino.
27. Mini project based on sensor applications in industrial systems

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Sensor Interfacing and Calibration:** Demonstrate the working of sensors and transducers using interfacing circuits, perform calibration and performance analysis, and explain their operation and industrial applications	20	–
2	**Sensor-Based Measurement System Development:** Develop a basic sensor-based measurement system using a temperature, light, or proximity sensor and present its working principle, interfacing method, and practical applications	–	10
	Total	20	10

Examination Style:

Sensor Interfacing and Calibration (20 Marks)
Students shall demonstrate the working of sensors and transducers using suitable interfacing circuits for measurement of physical parameters such as temperature, light intensity, displacement, or

	proximity. The activity shall include sensor selection, circuit setup, signal acquisition, observation recording, and calibration of the sensor using known reference values. Students shall analyze sensor performance by evaluating characteristics such as sensitivity, accuracy, linearity, range, and response. The assessment shall evaluate the student's ability to interface sensors with measurement systems, interpret sensor outputs, perform calibration procedures, and explain the operating principles and industrial applications of the selected sensor or transducer. The completed observation sheet, calibration data, calculations, and performance analysis shall be submitted during the examination. **Sensor-Based Measurement System Development (10 Marks)** Students shall develop a basic sensor-based measurement system using a temperature, light, or proximity sensor and demonstrate its operation. The activity shall include selection of the sensor, design of the interfacing circuit, acquisition of sensor data, and presentation of the working principle of the system. Students shall explain the interfacing method, output characteristics, and practical applications of the developed system in industrial, consumer, or automation environments. The report shall include circuit diagram, observations, measurements, analysis, results, and conclusions. The activity aims to enhance practical understanding of sensor technologies and their implementation in modern measurement systems.		
4	**Industrial Instrumentation Systems** ***Theory Topics:*** Industrial Instrumentation Systems covering process variables such as temperature, pressure, flow and level, measurement techniques for industrial parameters, signal transmission standards, industrial transmitters, control valves and actuators, process control basics, PLC fundamentals, SCADA basics, industrial data acquisition systems, and applications of instrumentation systems in process industries. ***Practical:*** 28. Measurement of temperature using RTD and thermocouple. 29. Study of pressure measurement systems. 30. Measurement of flow using flow measurement setup or simulation. 31. Study and testing of level measurement techniques. 32. Interfacing of industrial sensors with signal conditioning circuits. 33. Basic PLC programming and operation. 34. Study of industrial transmitters and actuators. 35. Data acquisition using sensors and microcontroller.	12	20%

36. Simulation of industrial control systems using Proteus or MATLAB.

37. Mini project based on industrial instrumentation applications.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Industrial Instrumentation Analysis:** Perform measurement of industrial parameters using instrumentation setup, analyze the performance of the instrumentation system through observations and report preparation, and explain the concepts and applications of industrial instrumentation system	20	–
2	**Industrial Process Measurement System Study:** Study an industrial process measurement system for temperature, pressure, flow, or level control and prepare a report explaining the instruments, sensors, and control methods used.	–	10
	Total	20	10

Examination Style:

Industrial Instrumentation Analysis (20 Marks)
Students shall perform measurement of industrial process parameters such as temperature, pressure, flow, or level using appropriate instrumentation setups, sensors, and measuring instruments. The activity shall include identification of the process variable, selection of suitable instruments, acquisition of measurement data, and recording of observations. Students shall analyze the performance of the instrumentation system by evaluating parameters such as accuracy, sensitivity, range, response time, and reliability. The assessment shall evaluate the student's understanding of process measurement techniques, instrumentation components, signal transmission methods, and practical implementation of industrial instrumentation systems. Students shall prepare a report containing observations, calculations, analysis, results, and conclusions, and explain the applications of the instrumentation system in industrial environments.

Industrial Process Measurement System Study (10 Marks)
Students shall study an industrial process measurement system used for temperature, pressure, flow, or level monitoring and control. The activity shall include identification of sensors, transducers, transmitters, controllers, actuators, and associated instrumentation components used

<table>
<tr><td></td><td>in the selected process. Students shall analyze the measurement and control methodology adopted in the system and explain the role of each component in achieving reliable process operation. The report shall include a process block diagram, working principle, instrumentation details, observations, analysis, industrial applications, and conclusions. The activity aims to develop an understanding of real-world industrial instrumentation systems and their significance in process monitoring and control.</td><td></td><td></td></tr>
<tr><td>5</td><td>Digital Instrumentation and Automation
<u>Theory Topics:</u>
Digital Instrumentation and Automation covering digital measuring instruments, data acquisition systems, ADC and DAC, microcontroller-based instrumentation, embedded instrumentation basics, automation systems, PLC and SCADA overview, industrial communication systems, smart instrumentation, IoT-based monitoring systems, and applications of digital instrumentation in industrial automation.
<u>Practical:</u>
38. Study of ADC and DAC interfacing circuits.
39. Data acquisition using sensors and microcontroller.
40. Interfacing of LCD or display unit with microcontroller.
41. Basic PLC programming for industrial automation.
42. Study of SCADA simulation environment.
43. Sensor monitoring using Arduino or microcontroller.
44. Mini project on automated measurement or monitoring system.
45. Interfacing of relay and actuator control circuits.
46. Simulation of automation systems using Proteus or MATLAB.
47. Development of simple IoT-based instrumentation application.

Evaluation Method:
<table>
<tr><th>Sr. No.</th><th>Evaluation Methods</th><th>SEE</th><th>CCE</th></tr>
<tr><td>1</td><td>Digital Instrumentation and Automation System Development: Develop and demonstrate a basic automation or monitoring system, prepare documentation with observation and performance analysis,</td><td>20</td><td>–</td></tr>
</table>
</td><td>15</td><td>20 %</td></tr>
</table>

	and explain the working of digital instrumentation and automation systems		
3	**Automation and Monitoring System Development (10 Marks):** Develop and demonstrate a simple automation or monitoring system using Arduino, PLC, or sensor interfacing and explain its industrial or real-life applications.	–	10
	Total	20	10

Examination Style:

Digital Instrumentation and Automation System Development (20 Marks)

Students shall develop and demonstrate a basic automation or monitoring system using digital instrumentation techniques. The activity shall involve interfacing sensors, actuators, displays, or control devices with a suitable platform such as Arduino, PLC, or other embedded systems. Students shall acquire, process, and monitor data from the connected devices and demonstrate the functionality of the developed system. The assessment shall evaluate the student's ability to integrate hardware components, implement control logic, record observations, and analyze system performance. Students shall explain the working principles of the digital instrumentation and automation system, identify its limitations, and discuss possible improvements. A detailed report containing circuit diagrams, program logic, observations, results, performance analysis, and conclusions shall be submitted during the examination.

Automation and Monitoring System Development (10 Marks)

Students shall develop and demonstrate a simple automation or monitoring system using Arduino, PLC, or sensor interfacing techniques. The activity shall include system design, hardware implementation, programming or control logic development, testing, and demonstration of the system functionality. Students shall explain the working principle of the developed system and identify its applications in industrial automation, smart monitoring, process control, or real-life scenarios. The report shall include system architecture, circuit or ladder diagrams, observations, results, analysis, applications, and conclusions. The activity aims to enhance practical skills in digital instrumentation, automation, and embedded system integration.

Suggested Specification table with Marks (Theory): 100

Distribution of Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	10%	15%	20%	10%	15%	30%

Course Out come:

After learning the course, the students should be able to:	
CO1	Explain the fundamentals of instrumentation systems, measuring instruments, and measurement techniques.
CO2	Apply electrical and electronic measurement methods for analysis of various electrical quantities.
CO3	Understand the working principles and applications of sensors and transducers used in industrial systems.
CO4	Analyze industrial instrumentation systems and process measurement techniques.
CO5	Develop basic automation and digital instrumentation systems using modern measurement and control techniques.

Instructional Method:

The course delivery method will depend on the requirements of the content and the needs of students. The teacher, in addition to the conventional teaching method by the blackboard, may also use any of the tools, such as demonstration, role play, quizzes, brainstorming, MOOCs, etc.

From the content, 10% of topics are suggested for flipped-mode instruction.

Students will utilize supplementary resources, including online videos, NPTEL/SWAYAM videos, e-courses, and Virtual Laboratories.

The internal evaluation will be done on the basis of the CCE-Continuous and Comprehensive Evaluation.

SEE: Semester End Evaluation will be conducted at the end of the semester for the evaluation of the performance of students in the laboratory.

Reference Books

[1] A. K. Sawhney, Electrical and Electronic Measurements and Instrumentation. New Delhi, India: Dhanpat Rai Publications.

[2] A. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques. Upper Saddle River, NJ, USA: Pearson Education.

[3] H. S. Kalsi, Electronic Instrumentation. New Delhi, India: McGraw-Hill Education.