GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Electrical Engineering
Subject Code: BE05009031
Subject Name: Measurement and Instrumentation

w.e.f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	NA
Rationale:	Measurement and Instrumentation is a core subject in electrical engineering that equips students with the knowledge and practical skills to accurately measure and analyze electrical and physical quantities in real-world systems. It plays a vital role in ensuring safety, efficiency, reliability, and quality across areas such as power systems, automation, renewable energy, smart grids, and embedded systems. The subject develops understanding of the principles, characteristics, and applications of both analog and digital instruments, bridging theory with practical engineering practice.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
CO-1	Recall the basics of electrical measurements. *(Cognitive Level: Remember-R)*
CO-2	Explain basic principle, working, characteristics and applications of the various measuring instruments and transducers. *(Cognitive Level: Understand-U)*
CO-3	Apply appropriate AC and DC bridge circuits and extension methods to measure and calculate resistance, inductance, capacitance, voltage, current, power, and energy. *(Cognitive Level: Apply - A)*
CO-4	Analyze measurement errors, distinguish different measurement methods and instruments for electrical parameters, and identify sources of errors in transducers and sensors. *(Cognitive Level: Analyze - N)*

CO-5	Evaluate and justify the suitability of a measurement system for a specified application by assessing overall performance against given criteria. *(Cognitive Level: Evaluate - E)*

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial/Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA(I)	PBL(I)	ESE(V)	
45	0	30	15	90	3	70	30	20	30	50	200

- ***Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Where L=Lecture, T=Tutorial, P=Practical, TH=Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Concepts of Measurement:** Measurement System, Classification of instrument system, Methods of Measurement, Static Characteristics like accuracy, precision, sensitivity, linearity, range, reproducibility, drift, threshold, dead zone etc. Dynamic Characteristics like speed of response, fidelity overshoot etc., Measurement Standards, Errors in measurement, Basic statistical evaluation of measurement data and errors -mean, standard deviation, Six sigma estimation, AI-based error correction	**06**	**15**
2	**Transducers and Sensors:** Definition, different types of transducers, criteria for selection, general characteristics and dynamic characteristics, Transducers for measurement of temperature like Thermocouple, Thermister and RTD and High temp thermal sensors, transducers for measurement of pressure, strain, transducers for measurement of displacement like LVDT, speed, torque, Hall Effect transducer, Sensors–basic concept–Speed and position sensors, Basics of IoT-enabled smart	**10**	**25**

	sensors		
3	**Measurement of Parameters :** Measurement of resistance, , Extending the range of meters - Shunts, Potential divider, Instrument Transformer and their applications in the extension of instrument range, Measurement of voltage, current, power, energy, power factor, frequency and harmonics (constructions and operating principles of corresponding instruments including Power quality analyzer) Instrument Transformer types -current transformer and potential transformer, Rogowski coil ,Residual Voltage ,current detection	**10**	**25**
4	**Measurement of R, L and C:** Different methods of measuring low, medium and high resistances, Earth Resistance Wheatstone Bridge, Measurement of inductance & capacitance with the help of AC Bridges (Hays Bridge, Schering Bridge, Maxwell bridge, Anderson Bridge De Sauty Bridge), LCR meter - working principle with block diagram, Auto-balancing bridge techniques	**12**	**25**
5	**Display and Devices:** Types of display elements Seven Segment Display, LED, LCD Application of ADC, DAC, and Sample & hold circuits in digital meter, DVM and Digital multimeter, Clampon meter, Megger Digital recorders, Digital Storage Oscilloscope - Types, Block Diagram, theory and applications including FFT spectrum analysis, Power scope.	**7**	**10**
	Total	**45**	**100**

The syllabus of the Measurement and Instrumentation addresses following SDGs:

SDG 7	Affordable and Clean Energy Accurate measurement of power, energy, and power quality, supports efficient energy use. It builds skills for sustainable energy management.
SDG 9	Industry, Innovation and Infrastructure Knowledge of sensors, transducers, and modern measurement systems used in industry supports innovation through smart sensors. Practical exposure to instruments strengthens industrial Infrastructure.
SDG 11	Sustainable Cities and Communities Modern sensors and monitoring systems support smart home and city development. Digital tools enable real-time monitoring of city systems, which contributes to sustainable and resilient communities.
SDG 12	Responsible consumption and production Accurate measurement and error reduction to minimize resource wastage enable responsible

	consumption. Monitoring of energy and parameters promotes sustainable production.

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**30**	**20**	**10**	**10**	**00**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References/Suggested Learning Resources:
Books:

1. Gupta J. B., "A Course in Electronics and Electrical Measurements and Instrumentation", S.K. Kataria & Sons
2. A.K.Sawhney, "Electrical and Electronic Measurements and Instrumentation", DHANPAT RAI & CO.
3. Golding & Widis, 'Electrical Measurement and Measurement instrument', Wheelar Books
4. D. Patranabis, 'Sensors & Transducers', PHI.
5. H. S. Kalsi, " Electronic Instrumentation", Tata McGraw-Hill Education.
6. A.J. Bouwens, 'Digital Instrumentation', Tata Mc-Graw hill.

Suggested Course Practical List:

1. Identify measuring instruments—accuracy, class, scale, dial markings
2. Measure medium resistance using Wheatstone Bridge
3. Measure low resistance using Kelvin's Double Bridge
4. Measure inductance using Universal Impedance Bridge
5. Measure capacitance using Universal Impedance Bridge
6. Measure insulation resistance using Megger
7. Use DSO for waveform, frequency & time measurement

8. Measurement of single-phase power using wattmeter
9. CT and PT testing and ratio/phase angle measurement
10. Calibration of voltmeter and ammeter using standard meters
11. Use of DMM and True RMS meters
12. Thermocouple/RTD temperature measurement
13. Strain measurement using strain gauge setup
14. Load cell calibration and measurement

Open-Source Simulation Software

1. Scilab – MATLAB alternative for numerical computations and control simulations.
2. Octave – Open-source alternative to MATLAB, useful for control system analysis.
3. PSIM (Student Version) – Used for power electronics and drive simulations.
4. LTspice – Free circuit simulation tool useful for modelling electrical systems.
5. OpenModelica – Open-source simulation software for electrical and mechanical systems.

Websites for Self-Learning

1. NPTEL (https://nptel.ac.in/) – Free online courses on measurement by IIT professors.
2. MIT Open Course Ware (https://ocw.mit.edu/) – Courses related to measurement/measuring instruments and power electronics.
3. ALL ABOUT CIRCUITS (https://www.allaboutcircuits.com/) – Tutorials and interactive content on measurement and power electronics.
4. Electrical4U (https://www.electrical4u.com/) – Conceptual explanations of electrical measuring instruments.
5. Texas Instruments (https://www.ti.com/) – Application notes on measuring instruments.
6. IEEE Xplore (https://ieeexplore.ieee.org/) – Research papers and white papers on measurement/measuring instruments advancements.

Interactive Learning Platforms

1. CircuitVerse (https://circuitverse.org/) – Online circuit simulation for basic electrical concepts.
2. SimulIDE (https://simulide.com/) – Open-source electronics simulation tool.
3. Khan Academy (https://www.khanacademy.org/) – Basic electrical engineering concepts.
4. edX & Coursera – Various free electrical engineering courses from top universities.

List of Laboratory Resources Required:

Necessary number of meters, accessories and instruments etc. to be provided to conduct the above experiments in a group of maximum 4 students. Charts and cut section models of various instruments should be provided for better understanding.

List of suggested activities for Problem Based Learning (PBL):

Sr. No.	Category	Activity	Suggested Hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research Laboratory Visit (e.g., manufacturing plant for Transducers and Sensors, R&D lab, etc.)	Visit = 5h, Report = 5h, Total = 10h	Report with observations, drawings, calculations based on actual data from visit
2	Video Based Learning	Technical Video-based Learning (MOOC/NPTEL, IEEE, All About topics like measurement, display devices, etc.)	Video = 5h, Report = 5h, Total = 10h	Summary/presentation of learning outcomes
		Self-learning online course (sensor installation safety, maintenance, etc.)	Minimum duration = 10h	Examination, certificate produced
		Creation of annotated video explaining concept (e.g., RLC measurement setup procedure)	10h	Accuracy, clarity, presentation
3	Assignment / Technical Writing / Research Writing	Numerical Assignments (errors in measurement, measurement of R, L, C etc. calculations)	5 assignments × 2h each = 10h	Accuracy and clarity of solved assignments
		Technical Article/Blog Writing on measurement topics	Research = 6h, Writing = 4h, Total = 10h	Originality, clarity, references
4	Complex Problem-Solving targeting relevant SDGs / Mini Project	Complex Problem Solving	2 problems × 5h each = 10h	Depth of analysis, correctness of solution
5	Research Paper Review / Analysis	Research Paper Discussion (WoS/SCOPUS/any reputed journals)	5 papers × 4h = 20h	Summary and critical analysis
6	Poster / Chart / PowerPoint Presentation	Poster/Chart/PPT on syllabus topics	6h	Quality, technical content, presentation
7	Micro Project	Working/Non-working Model on relevant subject	Working -5 h	Functionality/demo, innovation

8	Group Discussion / Quiz / Simulation	Group Discussion on emerging trends	10 discussions x 1h each = 10h	Depth of knowledge, contribution
		Online Technical Quizzes	multiple quizzes totaling 10 hours	Quiz scores and reflections
		Simulation/Coding Tasks in MATLAB/Scilab etc.	5 × 2h = 10h	Simulation results, code documentation, correctness
9	Case Study Analysis / Seminar	Case Study Analysis of real-world measurement system	Data collection = 5h, Report = 5h, Total = 10h	Data quality, analysis depth
10	Other	Find out various standards related to subject	Research = 5h, Report = 5h, Total = 10h	Knowledge gain, analysis, documentation

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Measurement and Instrumentation incorporates;
   Mini Project – 10 Marks and
   Micro Project – 5 Marks.
   These activities are integrated as core Project-Based Learning (PBL) components, aimed at promoting experiential learning, fostering innovation, and enhancing problem-solving skills through hands-on engagement in measuring bridges/instruments design, simulation, and analysis. The PBL approach supports the development of higher-order cognitive skills aligned with Bloom's taxonomy, while also strengthening teamwork, communication, and research competencies essential for professional engineering practice.
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activities should be related to the subject.
4. Rubrics for the evaluation can be prepared by the faculty.
5. All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level.

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