# GUJARAT TECHNOLOGICAL UNIVERSITY

**Program Name: Bachelor of Technology (Mechatronics)**
**Level: UG**
**Branch: Mechatronics**
**Subject Code: BE05020011**
**Subject Name: Electromechanical Measurement and Instruments**

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| w.e.f .Academic Year: | 2025-26 |
| Semester: | 5 |
| Category of the Course: | Professional Core Course |

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| **Prerequisite:** | Nil |
| **Rationale:** | Electromechanical Measurement and Instruments is designed to provide fundamental and applied knowledge of measurement systems, sensors, transducers, electrical instruments, and digital data acquisition techniques used in modern mechatronic and industrial applications. Accurate measurement and monitoring are essential for automation, quality assurance, energy optimization, predictive maintenance, industrial safety, and sustainable engineering practices.<br><br>This course enables students to understand the principles of measurement, calibration, signal conditioning, error analysis, and instrumentation required for reliable operation of electromechanical systems. The knowledge gained through this course supports the development of intelligent and energy-efficient systems used in manufacturing, transportation, healthcare, renewable energy, and smart infrastructure. |

**Course Objectives:** The objective of the course is to introduce the fundamentals and principles of measurement which includes the working mechanism of various sensors and devices that are in use to measure the important physical variables of various mechatronic systems.

**Course Outcomes:**

| Sr.No. | CO statement | Marks% weightage |
|---|---|---|
| CO-1 | Apply the knowledge gained for mechanical and electrical measurements in the field. | **30** |
| CO-2 | Design the multidisciplinary instruments for measurement of specific entity. | **30** |
| CO-3 | Finding the errors in the measuring system and rectifying them using calibration process. | **30** |
| CO-4 | Analyze the measured data/observations collected from the actual application for evaluating the system performance with respect to specifications and standards. | **10** |

**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 | Total no of hours per semester | | ESE (E) | PA / CA (M) | PA/CA (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.***

**Content:**

| Sr.No. | Content | Total Hrs |
|---|---|---|
| 1 | **Introduction** Introduction to Measurements and Instrumentation, Applications of Measurement, Significance of Measurements, Standards of Measurements, Methods of Measurements, Modes of Measurements, Classification of Instruments, Basic Standards and Units, Primary, Secondary and Working Standards, Generalized Measurement Systems and its Functional Elements, Input-Output Configurations of Measuring. | **6** |
| 2 | **Static & Dynamic Characteristics of Instrument and Errors in Measurements** Static Characteristics of Instrument, Calibration process of an Instrument, Dynamic Characteristics of Instrument, Standard Test Signals/Inputs, Zero, First and Second Order Systems, First Order System Responses, Second Order System Responses. Limiting Errors, Types of Errors, Sources of Errors, Statistical Analysis of Test Data, Application of Computers for Data Analysis, Selecting an Instrument for Measurement. | **12** |
| 3 | **Force, Torque & Power Measurements** Load Cells, LVDT, Elastic Force Transducer, Mechanical Torsion Meter, Optical Torsion Meter, Strain Gauge Torsion Meter, Electrical Torsion Meter, Mechanical, Hydraulic and Electrical Dynamometry. | **5** |
| 4 | **Speed, Acceleration and Frequency Measurements** Mechanical Tachometer, Electrical Tachometer, Contactless Electrical Tachometers, Piezoelectric Accelerometer, Seismic Acceleration. | **3** |
| 5 | **Principles of Operation of Electrical Instruments** Permanent Magnet Moving Coil and Moving Iron type instruments, DC Potentiometers and its applications, Resistance measurement: Different methods for measurement of high, low and medium resistance, Basics of instrument transformers (current transformers and potential transformers). | **10** |
| 6 | **Sensors and Transducers** Resistance Strain Gauges, Resistive Potentiometers and errors, Thermocouples and Thermoelectric laws, RTDs and Thermistors, Piezoelectric Sensors and loading effects, Inductive and Capacitive Transducers, Signal conditioning of sensors. | **5** |
| 7 | **Digital Data Acquisition Systems** Basic functional elements of Digital Data Acquisition Systems, Introduction to Data Transmission and Telemetry, Introduction to Digital Signal Processing. | **4** |
| | **TOTAL** | **45** |

**Suggested Specification table with Marks(Theory):(ForB.E.only)**

| Distribution ofTheory Marks | | | | | |
|---|---|---|---|---|---|
| RLevel | ULevel | ALevel | NLevel | ELevel | CLevel |

| | | | | | |
|---|---|---|---|---|---|
| 40% | 25% | 15% | 10% | 5% | 5% |

**R: Remembrance;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create and above Levels (Revised Bloom's Taxonomy)**

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

The syllabus of Electromechanical Measurement and Instruments directly contributes to

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| SDG 4 | Through skill-based learning in modern instrumentation and data acquisition systems. |
| SDG 7 | Affordable and clean energy |
| SDG 8 | Decent work and Economic growth |
| SDG 9 | Through the application of sensors, smart instrumentation, digital measurement systems, and industrial automation technologies. |
| SDG 12 | By promoting precise measurements, process optimization, reduction of wastage, and efficient utilization of resources. |
| SDG 13 | Through monitoring and control systems used in environmental measurements, emission monitoring, and sustainable industrial operations. |

**Reference Books:**


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|---|---|
| **1** | D. S. Kumar, Mechanical Measurement and Control, Metropolitan Book Co. |
| **2** | A. K. Sawhney, A course in Electrical and Electronic, Measurement and Instrumentation Dhanpat Rai & Sons. |
| **3** | R. K. Rajput, Mechanical Measurements and Instrumentation Katson Books. |
| **4** | T. G. Beckwith Mechanical Measurements Narosa Publishing House. |
| **5** | Nakra B.C. and Chaudhray K. K. Instrumentation, Measurement and Analysis Tata McGraw Hill. |
| **6** | E. O. Doeblin, Measurement Systems, McGraw Hill International Edition. |
| **7** | D. V. S. Murthy Transducers and Instrumentation Prentice Hall of India. |


**List of Experiments:**

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| **1** | To calibrate bourdon tube pressure gauge using dead weight gauge tester. |
| **2** | To calibrate RTD using liquid in glass thermometer. |
| **3** | To find the effect of temperature on the kinematic viscosity of a fluid. |
| **4** | Speed measurement of rotating shaft using different speed measuring instruments. |
| **5** | Torque measurement using rope brake and eddy current dynamometers. |
| **6** | To study the construction and working of PMMC and Moving iron instruments. |
| **7** | To extend the range of an ammeters and voltmeters. |
| **8** | Calibration of ammeters and voltmeters using DC potentiometers. |
| **9** | Measurement of Force using Load cell. |

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| **10** | Measurement of Linear displacement with the help of LVDT. |
| **11** | To understand calibration process using NI Sensor Kit. |
| **12** | Measurement and On-Off control of temperature using Thermocouples and Thermistors. |

**Major Equipment:**

**Nil**

**List of Open Source Software**

**Nil**

**List of learning website:**

| **Supplementary learning Material:** | |
|---|---|
| **1** | NPTEL and Coursera Resources |

**Pedagogy:**

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Seminar/Poster Presentation
- Industrial/ Field visits
- Course Projects

**List of suggested activities for Problem-based Learning (PBL):**

| Sr. No. | PBL category | Name of the activity | No. of hours | Evaluation Criteria |
|---|---|---|---|---|
| 1. | Complex Problem-Solving targeting relevant SDGs / Mini Project | Mini Project | 15h (need to be changed as per total PBL hours) | Based on the novelty of project, technical understanding, report quality and presentation |
| 2. | Case Study Analysis / Seminar | Seminar | 15h (need to be changed as per total PBL hours) | Based on the quality of report and presentation, technical understanding |
| 3. | Micro project | Micro project | 8h (need to be changed as per total PBL hours) | Based on the novelty of project, technical understanding, quality of report and demonstration |
| 4. | Industry/Research laboratory visit | Industry/Research laboratory visit | Visit = 5h, Report preparation = 5h Total = 10h | Based on report submitted. Report should contain observations and calculations based on industry/ lab data. |

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| 5. | Video Based Learning | Technical video-based learning related to the subject | Duration of video =5h<br>Report preparation = 5h<br>Total = 10h | Report /presentation based on the video learning outcomes. |
| 6. | Assignment / Technical Writing / Research Writing | Assignment writing. Numerical based assignment is preferable. | 5 assignments of 4 h each<br>Total = 20h | Based on the correctness of submitted assignment |
| 7. | Group Discussion / Quiz / Simulation | Problem solving/Coding using C, C++,MATLAB, Python, SCILAB,modeling and Analysis software or any other software | 5 small coding-based assignment of 2h each<br>Total = 10h | Based on the coding solution submitted. |
| 8. | Video Based Learning | Self-learning online course | Minimum duration of the course should be 10h | Examination based assessment at the end of course. Based on the certificate produced. |
| 9. | Complex Problem-Solving targeting relevant SDGs / Mini Project | Identification and solution of Complex problem | Maximum 2 problems. Study of the problem and solution finding,<br>Total =10h | Based on the depth of the solution submitted. |
| 10. | Video Based Learning | Videos on Industrial safety/Disaster Management aspects based on subject | Duration of video = 5h<br>Report preparation = 5h<br>Total = 10h | Based on quiz/report submitted |
| 11. | Research Paper Review / Analysis | Technical paper reading and summarization of research papers based on relevant subject | 5 research papers = 20h | Summarize research paper and evaluation critical parameters |
| 12. | Poster/Chart/PowerPoint presentation | Poster/chart/power point preparation on technical topics | Duration = 6h | Based on poster/chart preparation and presentation skills |
| 13. | Industry/Research laboratory visit | Industrial exposure for 2-3 days to observe and provide tentative solutions on | Duration = 15h for industrial exposure<br><br>Problem identification and | Based on evaluation of critical problems and solutions |

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| | | society/environment /health/sustainability /any other issue | tentative solution = 10h<br>Total = 20h | |
| 14. | Group Discussion / Quiz / Simulation | Group Discussion on emerging/trending technical topics based on subject | Duration = 1h – 3hper topic | Based on performance in group discussion, technical depth, knowledge etc. |
| 15. | Case Study Analysis / Seminar | Real world case studies-based learning | Duration of data collection/study = 5h<br>Report preparation = 5h<br>Total = 10h | Based on in-depth study, technical depth, data collected, fact finding, etc. |
| 16. | Group Discussion / Quiz / Simulation | Application/Softwar e development | Duration = 10h | Depending on the complexity of the Application/Software |
| 17. | Assignment / Technical Writing / Research Writing | Research paper publication | Duration = 10h | Based on submission of proof of publication |
| 18. | Micro project | Upgradation/Revers e engineering studies of existing equipment of the laboratory | Duration 10h | Based on the performance of the equipment |
| 19. | Industry/Research laboratory visit | Expert lecture/session | Duration 3h<br>For attending the lecture/session– 2h and for report writing 1h | Based on the proof of attendance<br>and report submitted |
| 20. | Video Based Learning | Annotated Video Explanation of Concept/Problem | 10h (Preparation + Recording + Submission) | Based on accuracy of explanation, clarity, and presentation style. |
| 21. | Assignment / Technical Writing / Research Writing | Patent Search and Innovation Gap Identification | 10h (Search + Report) | Based on number of relevant patents analyzed and identification of innovation scope. |
| 22. | Assignment / Technical Writing / Research Writing | Preparation of a report on Indian Standard(s) | 10h (study of Indian Standard(s) + report | Based on report quality and understanding of the relevant Indian Standard(s). |

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Electromechanical Measurement and Instruments compulsorily incorporates Micro Project and 5 marks as PBL activities for PEC and Seminar and Mini Project for PCC.**

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing 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 activity should be related to the subject.
4. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
5. Rubrics for the evaluation can be prepared by the faculty.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC