GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Mechanical Engineering
Subject Code: BE04000181
Subject Name: Mechanical Measurement & Metrology

w. e. f. Academic Year:	2025-26
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	
Rationale:	Measurement and Metrology deals with the application of science in Mechanical Engineering. It provides a means of assessing the suitability of measuring instruments, their calibration, and the quality control of manufactured products. A product that is not manufactured according to metrological specifications will have to incur heavy costs of comply with the specifications later. Any compromise in quality creates rapid negative sentiments in the market and cost of recovering the original market position would be quite high. Hence, an organization should strive towards a ZERO – DEFECT regime in order to survive in a highly competitive market, ensuring this aspect of manufacturing is the responsibility of a quality control engineer, who must be completely familiar with measurements and metrology and also their limitations. By educating in the area of Measurement and Metrology students will enable to seek employment in engineering upon graduation while, at the same time, provide a firm foundation for the pursuit of graduate studies in engineering.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Summarize various methods and terms used in mechanical measurements and metrology.	20
CO-2	Measure mechanical quantities like Force, Temperature, Pressure, Velocity, Acceleration, Strain and Torque.	25
CO-3	Apply concepts of metrology for gears, threads and Geometric tolerance and dimensioning	30
CO-4	Utilize various precision machines working based on Laser technology and coordinate measuring methods	10
CO-5	Students will discriminate capabilities of machining process by measuring surface finish of the component produced	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	SL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	TW/SL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Metrology, Linear and Angular Measurement:** Definition, objectives and concept of metrology, Need of inspection, Principles, process, methods of measurement, Classification and selection of measuring instruments and systems. Accuracy, precision and errors in measurement. System of measurement, Material Standard, Wavelength Standards, Subdivision of standards, Line and End standards, Classification of standards and Traceability, calibration of End bars, standardization. Slip gauges- Indian standards on slip gauge, method of selection of slip gauge, stack of slip gauge, adjustable slip gauge, wringing of slip gauge, care of slip gauge, slip gauge accessories, problems on building of slip gauges (M87, M112). Measurement of angles- sine bar, sine center, angle gauges, optical instruments for angular measurements, Auto collimator-applications for measuring straightness and squareness.	8
2	**System of Limits, Fits, Tolerance and Gauging:** Definition of tolerance, Specification in assembly, Principle of interchangeability and selective assembly, limits of size, Indian standards, concept of limits of size and tolerances, definition of fits, hole basis system, shaft basis system, types of fits and their designation (IS 919-1963), geometric tolerance, position-tolerances. Classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials. **Comparators:** Functional requirements, classification, mechanical- Johnson Mikrokator, sigma comparators, dial indicator, electrical- principles, , LVDT, Pneumatic- back pressure gauges, Solex comparators and optical comparators- Zeiss ultra-optimeter.	8
3	**Measurement of screw thread and gear:** Terminology of screw threads, measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope. Gear tooth terminology, tooth thickness measurement using constant chord method, addendum comparator method and base tangent method, measurement of pitch, concentricity, run out, and involute profile. Gear roll tester for composite error.	8
4	**Measurement systems and basic concepts of measurement methods:** Definition, significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system responsetime delay. Errors in measurement, classification of errors. Transducers, transfer efficiency, primary and secondary transducers, electrical, mechanical, electronic transducers, advantages of each type transducers. **Intermediate modifying and terminating devices:** Mechanical systems, inherent problems, electrical intermediate modifying devices, input circuitry, ballast circuit, electronic amplifiers. Terminating devices, Cathode ray oscilloscope, Oscillographs. Advances in metrology: Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications. Basic concepts of Coordinate Measuring Machines constructional features, applications.	8

5	**Force, Torque, Pressure, Strain and temperature Measurement:** Direct methods and indirect method, force measuring instruments Torque measuring instruments, Types of dynamometers, Absorption dynamometer, Prony brake and rope brake dynamometer, and power measuring instruments. Pressure measurement, principle, pitot tube, pressure gauges, pressure transducers, use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge. Theory of strain gauges, types, electrical resistance strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement. Temperature Compensation, Wheatstone bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors. Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, optical pyrometer.	**10**
6	**Metrology of Surface finish:** Surface Metrology Concepts and terminology, Analysis of surface traces, Specification of surface Texture characteristics, and Method of measuring surface finish: Stylus system of measurement, Stylus probe instruments, Wave length, frequency and cut off, other methods for measuring surface roughness: Pneumatic method, Light Interference microscopes, Mecrin Instruments.	**3**
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**10**	**35**	**00**	**40**	**00**

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (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.

Reference Books:

1. Engineering Metrology and Measurements, Bentley, Pearson Education
2. Metrology and Measurement, Anand Bewoor & Vinay Kulkarni McGraw-Hill
3. Mechanical Measurements and Instrumentations, Er. R K Rajput, Kataria Publication(KATSON)
4. Mechanical Measurement and Metrology by R K Jain, Khanna Publisher Mechanical Measurement & Control by D.S. Kumar. 5. Industrial Instrumentation & Control by S K Singh, McGrawHill 6. Engineering Metrology and Measurement, N V Raghavendra and Krishnamurthy, Oxford University Press

List of Experiments:

Following experiments are suggested for Laboratory work

1. Basic understanding of measurements and metrology: concepts, application, advantage and future aspects
2. Performance on linear and angular measurements and check different characteristics of measurements
3. Performance on Temperature measurements and check different characteristics of measurements and also do calibration
4. Performance on Temperature measurements and check different characteristics of measurements and also do calibration
5. Performance on Stress, strain and force measurements and check different characteristics of measurements and also do calibration
6. Performance on Speed/Velocity, acceleration measurements.
7. Performance on surface measurements 8. Performance on measurements of gears and screw threads

Major Equipment:

1. Temperature Measurements Equipments/Devices/Sensors
2. Stress/Strain/Force Measurements Equipments/Devices/Sensors
3. Surface Measurements Equipments/Devices/Sensors
4. Linear/Angular Measurements Equipments/Devices/Sensors
5. Resistive Potentiometer, Tachometers, Piezoelectric Accelerometer
6. Gears/Screw Threads Measurements Equipments/Devices/Sensors
7. Miscellaneous measurements equipments

List of Open Source Software/learning website:

http://nptel.ac.in/courses/112106138

List of suggested activities for Problem Based Learning:

Sr. No	Name of the Activity	No. of Hours	Evaluation Criteria
1	Industryl Research laboratory visit	Visit: 5h, Report preparation: 5h Total: 10h	Based on the report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Technical Video based learning related to the subiect	Duration of video: 5h Report preparation: 5h Total: 10h	Report /presentation based on the video learning outcomes.

3	Assignment writing Numerical based assignment is preferable.	5 assignments of 4h each. Total:20h	Based on the assignment submitted.
4	Problem solving/Coding using c, c++, Pyhon, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignments of 2h each. Total: 10h	Based on the coding solution submitted.
5	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding. Total: 10h/ problem	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subiect	Duration of video: 5h Report preparation: 5h Total: 10h	Based on quizlreport submitted
8	Discussion on research paper based on relevant subiect	5 research paper : 20h	Summarize research paper and evaluation critical parameters
9	P o ster/chartlPowerPoi nt preparation on technical topics	Duration:6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working : 12h Non- working: 8 h	Based on inter department/extemal evaluation
11		Duration: 15 h for industrial exposure Problem identification and tentative solution : 10h Total:25 h	Based on evaluation of critical problems and solutions
12	t2 Group Discussion on emerging/trending technical topics based on subiect	Duration: t h each	Based on performance in group discussion, technical depth, knowledge etc.
13	Real world case studies based learning	Duration of data collection/study: 5h Report preparation: 5h Total: 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.

14	ApplicatiorVSoftware development	Duration: 10 h	Depending on the complexity of the Application/Software
15	Depending on the complexity of the Application/Software	Duration 2 hrs. For attending the lecture/session - 2 hrs. and for report writing 2 h.	Based on the proof of attendance and report submitted
16	Blog or Technical Article Writing	10h (Research - 6h, Writing - 4h)	Based on originality, technical content, references cited, and clarity of communication.
17	Annotated Video Explanation of Concept / Problem	10h (Preparation * Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
18	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
19	Tech Blog/YouTube Channel Curation	10h (Content curation * Analysis)	Summary report on curated content and learning outcomes.
20	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
21	Maintenance or Troubleshooting Logbook	10h (For example: lab instruments, computer hardware)	Based on documented cases, approach, and resolution.

Activity Note

- All activities should be related to the subject.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, the total number of hours is fixed.
- For a course, min 3 activities must be carried out as per the availability of faculties and students. There is no limit for maximum number of activities.
- Rubrics for the evaluation can be prepared by the respective faculty member.
- Subject teachers can add the relevant activities from the above list other than those mentioned in the syllabus, with the consent of the head of the department and DQAC. .
- Subject coordinator shall identify activities from the above list as per the subject needs, they will also declare a list of activities wise hours, evaluation scheme and rubrics to students at the beginning of the semester.

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