

2022-23

# MECHANICAL ENGINEERING

MEASUREMENT AND METROLOGY



PREPARED BY  
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# **Techno India NJR Institute of Technology**



**Session 2022-23**

**Course File**

**Measurement and Metrology (6ME3- 01)**

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# RAJASTHAN TECHNICAL UNIVERSITY, KOTA

## Syllabus

3<sup>rd</sup> Year - VI Semester: B.Tech. : Mechanical Engineering

### 6ME3-01: MEASUREMENT and METROLOGY

**Credit: 2**  
**2L+0T+0P**

**Max. Marks: 100(IA:20, ETE:80)**  
**End Term Exam: 2 Hours**

SN	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	1
2	Concept of measurement: General concept of measurement, Need for measurement, Generalized measuring system, Units, Standards, Sensitivity, Readability, Range of accuracy, Precision, Accuracy Vs precision, Uncertainty.	3
	Repeatability and reproducibility, Errors in measurement, Types of error, Systematic and random error, Calibration, Interchangeability.	3
3	Linear and angular measurements: Linear measuring instruments: Vernier caliper, Micrometer, Interval measurements:- Slip gauges, Checking of slip gauges for surface quality, Optical flat, Application of limit gauges	3
	Comparators:- Mechanical comparators, Electrical comparator, Optical comparator, Pneumatic comparator;	2
	Sine bar, Use of sine bar, Limitations of sine bars, Sources of error in sine bars, Bevel protractor, Applications of bevel protractor.	3
4	Form measurement: Introduction, Screw thread measurement, Thread gauges, Measurement of gears: Gear errors.	2
	Surface finish measurement:-Introduction, Elements of surface texture, Analysis of surface finish, Methods of measuring surface finish, Straightness measurement, Flatness testing, Roundness measurements	3
5	Coordinate measuring machine (CMM):-Types of CMM, Features of CMM, Computer based inspection,	2
	Measurement of power, flow and temperature related properties Measurement of force, Accelerometer, Load cells, Bourdon tube. Torque measurement: Torque measurement using strain gauges, Torque measurement using torsion bars, Mechanical dynamometers.	3
6	Measurement of flow: Variable area meters – rotameter, Hot wire anemometer, Pitot tube.	3
	Temperature measurement, Bimetallic strip, Thermocouples (Thermo electric effects), Thermistors, Pyrometers	
<b>TOTAL</b>		<b>28</b>

### **Course Overview:**

Student will learn basics of measurement and metrology from this 29 hours course. Understand metrology, its advancements & measuring instruments, Acquire knowledge on different standards of length, calibration of End Bars, linear and angular measurements, Screw thread and gear measurement & comparators. Equip with knowledge of limits, fits, tolerances and gauging.

Acquire knowledge of measurement systems and methods with emphasis on different transducers, intermediate modifying and terminating devices., Understand the measurement of Force, Torque, Pressure, Temperature and Strain.

### **Course Outcomes:**

<b>CO. NO.</b>	<b>Cognitive Level</b>	<b>Course Outcome</b>
1	Synthesis	Student will be able to explain the basics of measurement, limits, fits.
2	Synthesis	Student will be able to identify the uses of gauges and comparators.
3	Synthesis	Students will be able to understand the significance of measurement system, errors.
4	Synthesis	Students will be able to understand interpret measurement of field variables like force, torque
5	Synthesis	Students will be able to comprehend the fundamentals of thermocouple and strain.

## Course Outcome Mapping with Program Outcome:

VI SEM												
Measurement & Metrology Year of study: 2020-21												
Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	2	1	0	0	0	1	0	1
CO2	3	2	3	3	2	0	0	0	0	0	0	1
CO3	3	2	2	3	1	1	0	0	0	1	0	1
CO4	2	1	2	3	1	1	0	0	0	1	0	1
CO5	2	3	2	3	3	2	0	0	0	1	0	1
<b>Average</b>	2.40	2.00	2.40	3.00	1.80	1.00	0.00	0.00	0.00	0.80	0.00	1.00

### Course coverage module wise:

Lecture No.	Unit	Topic
1	1	<b>INTRODUCTION:</b> Objective, scope and outcome of the course.
2	2	Student should be able to understand general concept of measurement
3	2	Student should be able to understand need for measurement, Generalized measuring system
4	2	Student should be able to understand Units, Standards, Sensitivity
5	2	Student should be able to understand Readability, Range of accuracy, Precision
6	2	Student should be able to understand Accuracy Vs precision, Uncertainty
7	2	Student should be able to understand Repeatability and reproducibility, Errors in measurement
8	2	Student should be able to understand Types of error, Systematic and random error
9	2	Student should be able to understand Calibration, Interchangeability
10	3	<b>LINEAR AND ANGULAR MEASUREMENTS:</b> Student should be able to understand Linear measuring instruments: Vernier caliper
11	3	Student should be able to understand Micrometer, Interval measurements:- Slip gauges
12	3	Student should be able to Checking of slip gauges for surface quality, Optical flat

13	3	Student should be able to understand application of limit gauges
14	3	<b>COMPARATORS:-</b> Student should be able to understand Mechanical comparators, Electrical comparator
15	3	Optical comparator, Pneumatic comparator
16	3	<b>SINEBAR:-</b> Student should be able to understand Sine bar, Use of sine bar, Limitations of sine bars, Sources of error in sine bars
17	3	Student should be able to understand Bevel protractor, Applications of bevel protractor
18	4	<b>FORM MEASUREMENT:</b> Student should be able to understand Screw thread measurement
19	4	Student should be able to understand thread gauges, Measurement of gears: Gear errors
20	4	<b>SURFACE FINISH MEASUREMENT:-</b> Introduction, Elements of surface texture, Analysis of surface finish
21	4	Student should be able to understand Methods of measuring surface finish, Straightness measurement, Flatness testing, Roundness measurements
22	5	<b>COORDINATE MEASURING MACHINE (CMM):-</b> Types of CMM, Features of CMM, Computer based inspection
23	5	<b>FORCE AND POWER MEASUREMENT:-</b> Student should be able to understand Measurement of power
24	5	Student should be able to understand flow and temperature related properties
25	5	Student should be able to understand Measurement of force, Accelerometer, Load cells, Bourdon tube
26	5	<b>TORQUE MEASUREMENT:-</b> Student should be able to understand Torque measurement using strain gauges
27	5	Student should be able to understand Torque measurement using torsion bars, Mechanical dynamometers
28	6	<b>MEASUREMENT OF FLOW:</b> Student should be able to understand Variable area meters rotameter, Hot wire anemometer, Pitot tube.
29	6	<b>TEMPERATURE MEASUREMENT:-</b> Student should be able to understand Bimetallic strip, Thermocouples (Thermo electric effects), Thermistors, Pyrometers

## TEXT/REFERENCE BOOKS

1. JAIN R.K, ENGINEERING METROLOGY, KHANNA PUBLISHERS, 1994, 17TH EDITION.
2. N.V RAGHAVENDRA AND L. KRISHNAMURTHY, ENGINEERING METROLOGY AND MEASUREMENTS, OXFORD UNIVERSITY PRESS, 2014.

### Course Level Problems (Test Items):

CO.NO.	Problem description
1	<p>A. Explain the terms Interchangeability, reproducibility, sensitivity, precision and accuracy as applied to the method of measurement, with example.</p> <p>B. Explain the types of error in measurement also compare systematic error random error.</p> <p>C. Write short notes on repeatability, uncertainty, calibration and standard deviation.</p> <p>D. Explain Gaussian error analysis in detail, also write down all the properties of normal distribution.</p>
2	<p>A. Explain the principle of sine bar and comment on its accuracy.</p> <p>B. Define comparators and elaborate its various types.</p> <p>C. Explain the method of using vernier calliper and micrometer in liner measurement with diagram.</p> <p>D. Explain bevel protractor and also write down the application of bevel protractor.</p>
3	<p>A. Why assessment of the surface texture is important.</p> <p>B. Elaborate various gear error and comment on the problem of gear measurement.</p> <p>C. Explain working and construction of Parkinson gear tester.</p> <p>D. Explain various methods of measuring surface finish.</p>
4	<p>A. Explain the advantages, specification and benefits of coordinate measuring machine.</p> <p>B. Explain various geometrical checks on machine tools and explain acceptance test for surface grinder.</p> <p>C. What is CMM, Explain the working principle of CMM.</p>

	D. Distinguish 'alignment test' from 'performance test' of machine tools with example.
5	A. Write short notes on Measurement of force and Measurement of power. B. Explain the temperature measurement by Bimetallic Strip. C. What do you mean by dynamometer. How are dynamometer classified. D. Explain the flow measurement by Pitot tube. E. What is Rotameter. Explain its principle and advantages.

### **Assessment Methodology:**

1. Practical exam in lab where they have to write readings of measuring tools.
2. Assignments one from each unit.
3. Midterm subjective paper where they have to write numericals.
4. Final paper at the end of the semester subjective.



## Teaching and Learning resources unit-wise:

### Unit-1

A. Introduction, objective, scope of the measurement and metrology

Video Tutorials: <https://youtu.be/HplEeBtJupY>

Theory concepts:

<https://www.slideshare.net/taruian/introduction-to-mechanical-measurements-and-metrology>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

### Unit-2

A. Concept of measurement

Video Tutorials: <https://youtu.be/636vqLnsInk>

Theory concepts:

<https://learnmech.com/basic-concept-of-measurement-interview-question-and-answers/>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

B. Repeatability and reproducibility

Video Tutorials: <https://youtu.be/M5LntTDiKBQ>

Theory concepts:

<https://www.nap.edu/resource/25303/Metrology%20Perspective%20on%20Reproducibility.pdf>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

## Unit-3

### A. Comparators

Video Tutorials: <https://youtu.be/V91es3rBOyY>

Theory concepts: <https://extrudesign.com/comparator-types>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

### B. Linear and angular measurements

Video Tutorials: <https://youtu.be/BqAmLOI8uzs>

Theory concepts: <https://www.slideshare.net/taruian/l2-linear-and-angular-measurements>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

## Unit-4

### A. Form measurement

Video Tutorials: [https://youtu.be/\\_KhMhFRehy8](https://youtu.be/_KhMhFRehy8)

Theory concepts:

<http://www.gate-exam.in/ME/Syllabus/Materials-Manufacturing-Industrial-Engineering/Metrology-Inspection/Form-Finish-Measurement>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

### B. Surface finish measurement

Video Tutorials: <https://youtu.be/74oxalfdNuQ>

Theory concepts: [http://site.iugaza.edu.ps/aabuzarifa/files/METRO20152\\_CH81.pdf](http://site.iugaza.edu.ps/aabuzarifa/files/METRO20152_CH81.pdf)

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

## Unit-5

### A. Coordinate measuring machine

Video Tutorials: <https://youtu.be/VzzdtuGyt7A>

Theory concepts:

<https://theengineeringblog.com/coordinate-measuring-machine-working-types-applications-advantages-software-sensors-calibration/>

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

### B. Measurement of flow

Video Tutorials: <https://youtu.be/GTLIxFEV6iA>

Theory concepts: [https://en.wikipedia.org/wiki/Flow\\_measurement](https://en.wikipedia.org/wiki/Flow_measurement)

Sample Quiz: <https://www.sanfoundry.com/1000-engineering-metrology-questions-answers/>

Previous Year Question Papers:

RTU paper	Roll No. <u>15EE2ME009</u>	Total No. of Pages : <u>2</u>
	<b>5E6203</b>	
<b>5E6203</b>	B.Tech. V Semester (Main/Back) Examination, Nov./Dec. - 2017 Mechanical Engineering 5ME3A Measurement & Metrology Common With PI	

Time : 3 Hours

Maximum Marks : 80  
Min. Passing Marks : 26

Instructions to Candidates :

*Attempt any five questions, selecting one question from each unit. All Questions carry equal marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly). Units of quantities used/calculated must be stated clearly.*

**Unit - I**

1. a) List the various measurement methods and explain. (8)  
b) Describe the different types of errors in measurements and their respective causes. (8)

**OR**

1. a) Make a comparison between accuracy and precision. (8)  
b) Briefly discuss on calibration of temperature measuring devices with suitable examples. (8)

**Unit - II**

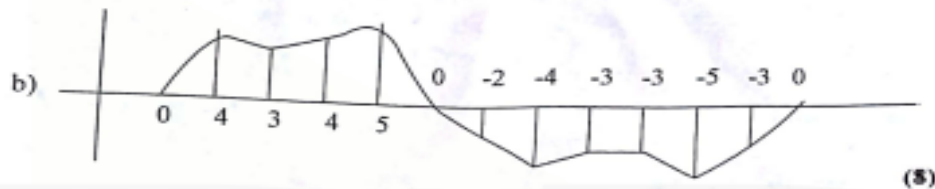
2. a) Differentiate the "Linear measuring instruments" and "Interval measuring instruments" with suitable examples. (8)  
b) Explain the working principle of mechanical comparator with neat sketch. (8)

**OR**

2. a) State and explain the "Taylor's principle" of gauge design. (8)  
b) Explain the principle and construction of an auto-collimator with neat sketch. (8)

**Unit - III**

3. a) Describe the two wire method of finding the effective diameter of screw threads. Given the figure below indicating stylus height values for a surface roughness measurement, find the Ra and Rq value. (8)



**OR**

3. a) What are the various methods used for measuring the gear tooth thickness? Explain them with neat sketches. (8)
- b) How to check the composite errors of the gear by using Parkinson gear testing machine? Explain it in detail? (8)

**Unit - IV**

4. With neat sketch explain the various types of CMM based on its construction. Write the advantages of computer aided inspection. (16)

**OR**

4. a) How the angle is measured using a laser interferometer? (8)
- b) Explain the acceptance tests for surface grinders. (8)

**Unit - V**

5. a) State any four inferential types of flow meters. Briefly explain various methods of measuring flow. (8)
- b) What is the principle involved in fluid expansion thermometer? Briefly explain various methods of measuring temperature. (8)

**OR**

5. Write short note on : Venturimeter, Pitot tube, Pyrometer and Rotameter. (16)