GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: PG
Branch: Mechanical Engineering
Course / Subject Code: ME01079021

Course / Subject Name: Advance Metrology and Experimental Techniques

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Nil
Rationale:	Present scenario of Industry 4.0, high-technology products, the most important requirements of dimensional and other accuracy controls are becoming very stringent as a very important aspect in achieving quality and reliability in the service of any product in dimensional control. Unless the manufactured parts are accurately measured, assurance of quality cannot be given. In this context, the course deals with modern inspecting techniques along with the classical metrology. Course also deals with design of experiments and techniques for analysis of acquired data, CMM and Machine Vision technology.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Demonstrate fundamentals of metrology.
02	Practice on data analysis and design of experiments.
03	Apply Laser Metrology and Holography
04	Perform advanced techniques used in metrology like CMM and Machine Vision

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** Concept of accuracy, Need for high precision measurement, Accuracy of numerical control system, Inaccuracy due to thermal aspects, Detailed surface roughness concept, Dimensioning & Dimensional chains, Surface and form metrology flatness, roughness, waviness cylindricity, Methods of improving accuracy & surface finish, Influence of forced vibration on accuracy, Dimensional wear of cutting tools and its influences on accuracy.	9	20
2.	**Analysis of Experimental Data:** Causes and Types of Experimental Errors, Error Analysis on a Commonsense Basis, Uncertainty Analysis and Propagation of Uncertainty, Evaluation of Uncertainties for Complicated Data Reduction, Statistical Analysis of Experimental Data, Probability Distributions, The Gaussian or Normal Error Distribution, Comparison of Data with Normal Distribution, The Chi-Square Test of Goodness of Fit, Method of Least Squares, The Correlation Coefficient, Multivariable Regression, Standard Deviation of the Mean, Students t Distribution, Graphical Analysis and Curve Fitting, Choice of Graph Formats, Causation, Correlations, and Curve-fits, General Considerations in Data Analysis.	9	20
3.	**Design of Experiments:** Introduction, Types of Experiments, Experiment Design Factors, Experiment Design Protocol and Examples.	4	10
4.	**Laser Metrology:** Free electron laser – optical alignment, measurement of distance – interferometry, reversible counting, refractive index correction, 07 15 reversible counting, refractive index correction, surface topography and optical component testing, beam modulation telemetry, pulse-echo techniques surface velocity measurements using speckle patterns – laser spectroscopy – modular beam spectroscopy, saturation spectroscopy, two photon spectroscopy.	7	12
5.	**Holography**: Basic principles, holographic interferometry, double exposure holographic interferometry, sandwich holograms, real time holography, time-average holographic interferometer, Character recognition.	4	10
6	**Coordinate Measuring Machine:** Co-ordinate metrology, CMM configurations, hardware components, Software, Probe sensors, Displacement devices, Performance Evaluations, Dynamic errors,	6	14

	Thermal effects diagram, Temperature variations environment control, applications.		
7	**Machine Vision and Image Processing**: Machine vision systems, Illumination, Magnification, Vision system measurement multi-sensory systems. Overview of Image Processing, Computer imaging systems, Image Analysis, Preprocessing, Human vision system, Image model, Image enhancement, gray scale models, histogram models, Image Transforms.	6	14
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**20**	**25**	**25**	**10**	**10**

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

References/Suggested Learning Resources:

(a) Books:

1. Experimental Methods for Engineers Holman J P, McGraw-Hill.
2. Industrial Metrology Smith G, Springer.
3. Fundamentals of Dimensional Metrology, Dotson C. Cengage.
4. Metrology and Measurement Bewoor, A. K. and Kulkarni V. A., McGraw-Hill.
5. Image Processing, Analysis, and Machine Vision Sonka M, Hlavac V, and Boyle R Cengage.
6. Co-ordinate Measuring Machines and Systems Bosch J A, Giddings and Lewis Dayton, Marcel Dekker.
7. Understanding and Applying Machine Vision Nello, Z. Marcel Dekker.
8. Lasers – Principles, Types and Applications Nambikar K, New Age International Limited Publishers.
9. Lasers – Principles and Applications Wilson J and Hawker J F B Prentice Hall.
10. Springer Handbook of Metrology and Testing Horst Czichos, Tetsuya Saito, Leslie Smith Springer
11. Engineering Metrology – K.J. Hume, Macdonald and Co.(publisher) London
12. The Metrology Hand book- Jay. L. Bucher (ed), American Society for Quality, 2004
13. Industrial Metrology – Smith GT, 2002, Spinger
14. Hand book of industrial metrology – John W. Greve, Frank W. Wilson, PHI – New Delhi
15. Engineering Metrology – D.M. Anthony, Pergamon Press
16. Dimensional Metrology – Khare MK, OXFORD-IBH Publishers

(b) Open source software and website:

1. NPTEL

Suggested Course Practical List: If any

1. Measurement of surface finish of a polished components.
2. Measurement of flatness of a surface plate.
3. Evaluation of roundness and cylindricity.
4. Statistical analysis using experimental data.
5. Analysis of Variance (ANOVA)
6. Measurement of Geometric and Form features using CMM.
7. Creation of CAD data from a physical component using CMM.
8. Generation of surface from point cloud using CMM.
9. Depth measurement using vision system (stereoscopic image).

List of Laboratory/Learning Resources Required:

Suggested Project List: Mini Project on above content.

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