

GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL (CAD/CAM) (08)

ADVANCED METROLOGY AND EXPERIMENTAL TECHNIQUES

SUBJECT CODE: 2710808

M.E. 1st SEMESTER

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: The student will be exposed to modern inspecting techniques along with the classical metrology. Along with the metrology, design of experiments and techniques for analysis of acquired data are also included in the course

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
4	0	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module 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.	07	15
2	Analysis of Experimental Data: Causes and Types of Experimental Errors, Error Analysis on a Common sense 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, <i>Students t</i> -Distribution, Graphical Analysis and Curve Fitting, Choice of Graph Formats, Causation, Correlations, and Curve-fits, General Considerations in Data Analysis	08	20
3	Design of Experiments: Introduction, Types of Experiments, Experiment Design Factors, Experiment Design Protocol and Examples.	05	10
4	Laser Metrology: Free electron laser – optical alignment, measurement of distance – interferometry, reversible counting, refractive index correction, 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.	8	15
5	Holography:	05	10

	Basic principles, holographic interferometry, double exposure holographic interferometry, sandwich holograms, real time holography, time-average holographic interferometer, Character recognition		
6	Coordinate Measuring Machine: Co-ordinate metrology, CMM configurations, hardware components, Software, Probe sensors, Displacement devices, Performance Evaluations, Dynamic errors, Thermal effects diagram, Temperature variations environment control, applications.	08	15
7	Machine Vision and Image Processing: Machine vision systems, Illumination, Magnification, Vision system measurement multisensory 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	12	15

Reference 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

List of Experiments:

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).

Open Ended Problems:

1. Evaluation of no. of points on the accuracy of hole feature using CMM
2. Perform DoE exercise for optimizing experimentation parameters of various manufacturing processes

Course Outcome:

After learning the course the students should be able to

1. Students will conceptualize fundamentals of metrology.
2. Students will be able to apply concepts of data analysis and design of experiments.
3. Students will learn advanced techniques used in metrology.