METROLOGY

ENME 204

Lecture : 3 **Year : II**
Tutorial : 0 **Part : I**
Practical : 1.5

Course Objectives:
The objective of this course is to impart knowledge of the fundamental principles of metrology, its significance in engineering, various measurement techniques and instruments, and apply the concepts of metrology for quality control and precise measurement of manufactured products.

1 Introduction (1 hour)

1.1 Definition, concept, need and importance of metrology
1.2 Types of metrology (Industrial, legal, dynamic and deterministic)
1.3 Classifications of measuring methods
1.4 General metrological terms: Accuracy, precision, repeatability, reproducibility, sensitivity, resolution and stability

2 Measurement Errors and Uncertainty (2 hours)

2.1 Sources of measurement errors
2.2 Classification of errors: Systematic, random, and gross errors
2.3 Uncertainties: Types, related calculations on uncertainties
2.4 Line of best fit
2.5 The effects of averaging results

3 Standards of Measurements (3 hours)

3.1 Introduction
3.2 Material standards
3.3 Wavelength standard
3.4 Sub-division of standard
3.5 Line and end measurements
3.6 Calibration of instruments and traceability
3.7 Nepal bureau of standards and metrology (Formation, duties and responsibilities)

4 Linear, Angular and Taper Measurement (6 hours)

4.1 Instruments for linear measurements (Types, principles, applications, limitations and errors): Vernier calipers, micrometers, Vernier height gauge, Vernier depth gauge, slip gauges, dial indicators, combination set

4.2 Instruments for angular measurements (Types, principles, applications, limitations and errors): Bevel protractors, sine bar, sine table, sine centre, angle gauges, spirit level, clinometers, auto-collimator, angle dekkor
4.3 Gauges for taper shafts
4.4 Measurement for taper shafts and holes

5 Comparators (3 hours)

5.1 Basic principle of measurement
5.2 Classification of comparators
5.3 Advantages and disadvantages of various types of comparators

6 Interferometry (2 hours)

6.1 Introduction
6.2 Principle of interference
6.3 Light source for interferometer
6.4 Optical flat
6.5 Types of interferometers: Configurations, applications and working methods

7 Limits, Fits and Tolerances (5 hours)

7.1 Basic terminology related to limits, fits and tolerances
7.2 Types of fits: Interference, transition and clearance fits
7.3 ISO system of limits and fits
7.4 Selection and calculation of fits and tolerances
7.5 Principle of interchangeability
7.6 Selective assembly
7.7 Fundamentals of geometric tolerances: Tolerances on shape or form, tolerance on orientation and tolerances on position

8 Gauges (4 hours)

8.1 Classification of plain gauges
8.2 Taylor's theory for gauge design
8.3 Gauge design of workshop gauge, inspection gauge and general gauge (First system, second system and third system)
8.4 Gauges for tapers
8.5 Related problems on limits, fits and tolerances, selective assembly and gauge design

9 Measurement of Surface Finish (3 hours)

9.1 Factor affecting surface roughness
9.2 Reasons for controlling surface texture
9.3 Orders of geometrical irregularities
9.4 Elements of surface texture

9.5 Evaluation of surface texture
9.6 Surface roughness measurement techniques
9.7 Related problems on surface roughness measurement

10 Gear Measurement (3 hours)

10.1 Gear tooth terminology
10.2 Measurement and testing of spur gears
10.3 Tooth thickness measurement
10.4 Measurement of pitch, concentricity, run out and involute profile
10.5 Tooth bearing contact testing
10.6 Composite method of gear testing

11 Measurement of Screw Threads (3 hours)

11.1 Terminology of screw thread
11.2 Errors in threads
11.3 Effects of pitch errors
11.4 Measurement of major diameter, minor diameter, pitch, angle and effective diameter of screw threads by 2-wire and 3-wire methods
11.5 Calculation of best wire size
11.6 Screw thread gauges

12 Acceptance Tests for Machine Tools (2 hours)

12.1 Introduction to acceptance tests
12.2 Equipment required for geometrical tests
12.3 Alignment or geometrical tests of machine tools
12.4 Performance test

13 Measuring Machines (2 hours)

13.1 End bar measuring machine
13.2 Universal measuring machine
13.3 Coordinate measuring machine (CMM)
13.4 Computer controlled coordinate measuring machine

14 Quality Control Management (6 hours)

14.1 Quality, quality control, quality assurance, total quality control, quality circle, total quality management, ISO 9000 series of quality system
14.2 Statistical quality control in engineering production - process variability, process capability, control charts, sampling inspection
14.3 Sampling plan
14.4 Related problems on statistical quality control (Standard deviation, normal distribution, probability, control charts)

Practical **(22.5 hours)**

1. Mechanical component measurement using Vernier caliper, micrometer and Vernier height gauge
2. Determination of unknown angle using spirit level, bevel protractor and sine bar
3. Spur gear measurement using Vernier tooth caliper
4. Calibration of micrometer using slip gauge
5. Study and use Gauges: Filler, radius, thread, wire, Go and No-Go gauges
6. Performance on measurement of screw thread
7. Performance on surface finish measurement
8. Study on the effect of cutting variables on surface roughness
9. Measurement of straightness, flatness and roundness
10. Alignment test on lathe, drilling and milling machine
11. Experiment to measure process capability using statistical process control

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1 and 2	3	6
3	3	4
4	6	6
5	3	4
6	2	4
7 and 8	9	9
9	3	4
10	3	5
11	3	5
12	2	4
13	2	4
14	6	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Mahajan, M. (2012). A Text book of Metrology (1st edition), India: Dhanapat Rai & Co., (P) Ltd.
2. Rajput, R. K. (2013). Engineering Metrology and Instrumentation (1st Edition), India: S. K. Kataria and Sons.
3. Jain, R. K. (2022). Engineering Metrology (22nd edition), India, Khanna Publishers.
4. Galyer, J. F. W., Shotbolt, C. R. (1988), Metrology for Engineers (5th edition), United Kingdom: Cassell.
5. Raghavendra, N.V., Krishna Murthy, L. (2013), Engineering Metrology and Measurement (1st edition), India: Oxford University Press.