METROLOGY AND INSTRUMENTATION

ENIE 251

Lecture : 3 **Year : II**
Tutorial : 1 **Part : II**
Practical : 3/2

Course Objectives:
The objective of this course is to provide basic concepts of metrology, mechanical measurement, instrumentation, calibration, and control systems, emphasizing practical applications and international standards.

1 Introduction to Metrology (2 hours)

1.1 Objectives, types and scope of metrology
1.2 Metrological terminology: Accuracy, precision, repeatability, reproducibility, sensitivity, resolution, calibration, magnification, backlash, range, span, traceability, drift, response, stability
1.3 Measurement and its standards
1.4 Errors: Types and sources of errors

2 Mechanical Measurement (4 hours)

2.1 Concept and types: Linear, angular and surface measurement
2.2 Line standard, end standard and wavelength standard
2.3 Construction, working principle and types of linear measuring instrument: Vernier caliper, micrometer screw gauge, steel rule, calipers, divider, telescopic gauge, depth gauge, screw pitch gauge, radius and feeler gauge, slip gauges or gauge blocks, comparator, dial indicator
2.4 Construction, working principle and types of angular measuring instrument: Engineering square, combination set, protractor, adjustable bevel, spirit level
2.5 Construction, working principle and types of surface measuring instrument: Surface plate, surface gauge, straight edge

3 Limit, Fit and Tolerance (5 hours)

3.1 Terms: Tolerance, allowance, fit, basic size, actual size, nominal size
3.2 Classification of fits
3.3 Hole basis and shaft basis system
3.4 Interchangeability and selective assembly
3.5 ISO system of limits, fits, tolerances and gauges
3.6 Taylors principle of gauge design
3.7 Related problem of ISO system of limits, fits and gauge design

4 Machine Tool Metrology (2 hours)

4.1 Geometrical test and performance test
4.2 Alignment tests
4.3 Flatness tests
4.4 Straightness tests
4.5 Spindle tests

5 Calibration and Verification (4 hours)

5.1 Importance of calibration and verification
5.2 Calibration of proving ring
5.3 Calibration and verification of universal testing machine, taxi meter, dispensing pumps
5.4 Verification of commercial and electronic balances
5.5 Verification and calibration of length standards (Standard meter bar, gauge block, micrometer, caliper, screw gauge, straightness, flatness, parallelism, circulatory, rotation)
5.6 Verification and calibration of ammeter; Voltmeter; Ohmmeter and multi-meter

6 Basic Concept of Instrumentation and Control System (4 hours)

6.1 Principle, needs and application of instrumentation and control system
6.2 Components of instrumentation and control system
6.3 Open loop and closed loop control system with examples
6.4 Types of control system: Cascade, ratio, feed-forward and split range
6.5 Effect of feedback on system gain, stability, noise and sensitivity

7 Transducers (6 hours)

7.1 Classification of transducer
7.2 Resistive transducer: Potentiometer, strain gauge and resistor temperature dependent-working, wheat stone bridge and their applications
7.3 Inductive transducer: Linear variable differential transformer (LVDT)-working and its applications
7.4 Capacitive transducer: By varying overlapping area, distance and permittivity of dielectric between plates (Working and applications)
7.5 Piezoelectric and hall effect transducers (Working and applications)
7.6 Thermistors and thermocouples (Working and applications)

8 Static and Dynamic Characteristics of Measuring System (8 hours)

8.1 Static characteristics of measuring system: Accuracy and precision, tolerance, range or span, linearity, sensitivity of measurement, threshold, resolution, sensitivity to disturbance, hysteresis effects, dead space

8.2 Dynamic characteristics of measuring system: Amplitude response, frequency and phase response, rise time and delay
8.3 Mathematical modeling and characteristics of systems: First order and second order system
8.4 Physical examples of first order and second order systems
8.5 Solution of system of first order and second order differential equation using Laplace transform
8.6 Modeling of mechanical (Mass, spring, damper) and electrical components (Inductance, capacitance, resistance, DC and AC motor, transducer and op-amp)

9 Measurement of Mechanical System (7 hours)

9.1 Force, moment and torque measurement: Elastic transducers, strain gauge load cells, piezoelectric load cells, dynamometers
9.2 Pressure measurement: Static and dynamic pressure measurement systems, pressure transducers types, measurement of low and high pressure, acoustical measurement
9.3 Fluid flow measurement: Obstruction meters for incompressible and compressible fluids, variable area flow meter, measurement of fluid velocities, pressure probes
9.4 Temperature measurement: Use of bimetals, pressure thermometer, thermoelectric thermometry, thermos-resistive elements, thermocouples, linear quartz thermometer, pyrometer
9.5 Gear measurement: Gear tooth terminology, measuring techniques, sources of error in gear measurement
9.6 Screw thread measurement: Types of thread, screw thread terminology, measuring techniques, sources of error in screw thread
9.7 Surface measurement: Elements and symbol of surface finish, methods of measuring surface finish

10 Organizations Concerning Metrology (3 hours)

10.1 Historical background, current status and future probabilities in the field of legal metrology in Nepal
10.2 Role of Nepal Bureau of Standards and Metrology (NBSM) and Organization International De Metrology Legal (OIML) in the field of legal metrology
10.3 Formulation and implementation of Nepalese standards and certification marks scheme
10.4 Formation, duties and responsibilities of Bureau International De Poids Et Measures (BIPM), OIML, Conférence générale des poids et mesures (CGPM), International Electro-Technical Commission (IEC), Asia Pacific Metrology Programmed (APMP)
10.5 Evolution of SI system of units

Tutorial **(15 hours)**

1. Errors in measurement
2. Least count, linear, angular and surface measurement
3. Limit, fit and gauge design
4. Static and dynamic characteristics
5. Gear and screw measurement

Practical **(22.5 hours)**

1. Errors in measurements and practical metrology
2. Demonstration and use of various linear, angular and surface measuring instrument
3. Familiarization of limit, fit and tolerance and different types of gauges
4. Demonstration of open loop and close loop system
5. Familiarization with different types of Transducers and study their static and dynamic characteristics
6. Calibration of measuring instrument: Proofing ring, UTM, taxi meter, dispensing pump

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	6	8
3 and 4	7	10
5 and 10	7	10
6 and 7	10	14
8 and 9	15	18
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Krishnamurthy, R. (2013). Engineering Metrology and Measurements. India: OUP India.
2. Jain, R. K. (2018). Mechanical and Industrial Measurements (12th Edition). India: Khanna Publishers.
3. Murthy, D.V.S. (2008). Introduction to Transducers and Instrumentation (2nd Edition). PHI Learning Pvt. Ltd.
4. Mahajan, M. (2014). A Textbook of Metrology. Dhanpat Rai & Co.
5. Morris, A. S., Langari, R. (2015). Measurement and Instrumentation: Theory and Application. Elsevier.
6. Nise, N. S. (2019). Control Systems Engineering. Wiley.
7. Mekid, S. (2009). Metrology and Instrumentation: Practical Applications for Engineering and Manufacturing. Wiley.