

| Course code   | Course Name                   | L-T-P-Credits | Year of Introduction |
|---|-------------------------------|---------------|----------------------|
| ME312   | METROLOGY AND INSTRUMENTATION | 3-0-0-3       | 2016                 |
| <b>Prerequisite: Nil</b>  |                               |               |                      |
| <p><b>Course Objectives:</b></p> <ul style="list-style-type: none"> <li>• To understand the working of linear and angular measuring instruments.</li> <li>• To familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges.</li> <li>• To give basic idea about various methods for measurement of screw thread and surface finish parameters.</li> <li>• To give an exposure to advanced measuring devices and machine tool metrology.</li> <li>• To provide students an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.</li> <li>• To provide basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.</li> </ul> |                               |               |                      |
| <p><b>Syllabus</b></p> <p>Introduction to Metrology - Errors in Measurement- Basic standards of length - Linear Measurement, Comparators - Angular Measurement - Limits and Limit gauges - Optical Measuring Instruments - Screw thread measurement - Measurement of surface texture - Machine tool metrology - Coordinate Measuring Machine (CMM) and Machine Vision.<br/> Introduction to Mechanical Measurement - Motion and Dimension measurement, Strain and Stress Measurement - Measurement of Force, Torque and Temperature Measurement.</p>  |                               |               |                      |
| <p><b>Expected outcome:</b></p> <p>The students will be able to</p> <ol style="list-style-type: none"> <li>i. Understand the working of linear and angular measuring instruments.</li> <li>ii. Know the fundamentals of limits and limit gauges, various methods for measurement of screw thread and surface roughness parameters and the working of optical measuring instruments.</li> <li>iii. Get an exposure to advanced measuring devices and machine tool metrology.</li> <li>iv. Acquire an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.</li> <li>v. Get basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.</li> </ol>                           |                               |               |                      |
| <p><b>Text books</b></p> <ol style="list-style-type: none"> <li>1. Anand K Bewoor, Vinay A Kulkarni, Metrology &amp; Measurement, McGraw-Hill, 2009</li> <li>2. Ernest O. Doebelin, Dhanesh N. Manik, Measurement Systems Application and Design, McGraw-Hill, 2004</li> <li>3. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS,1990</li> <li>4. Thomas G. Beckwith, John H. L., Roy D. M., Mechanical Measurements, 6/E , Pearson Prentice Hall, 2007</li> </ol>  |                               |               |                      |

**Reference books**

1. ASME, Hand book of Industrial Metrology,1998
2. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.,1990
3. J.P.Holman, Experimental Methods for Engineers,Mcgraw-Hill, 2007
4. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.,1958

**Course Plan**

| <b>Module</b>                     | <b>Contents</b>  | <b>Hours</b> | <b>End Sem. Exam. Marks</b> |
|-----------------------------------|--|--------------|-----------------------------|
| <b>I</b>                          | Concept of measurement:-Introduction to Metrology; Need for high precision measurements; Terminologies in Measurement-Precision, accuracy, sensitivity, calibration. | <b>1</b>     | <b>15%</b>                  |
|                                   | Errors in Measurement, types of errors, Abbe's Principle.  | <b>1</b>     |                             |
|                                   | Basic standards of length- Line standard, End standards, Wavelength standard; Various Shop floor standards.  | <b>1</b>     |                             |
|                                   | Linear Measurement – Slip gauges, wringing, grades; Surface plate; Dial indicators; Height gauges and Vernier calipers.  | <b>1</b>     |                             |
|                                   | Comparators- mechanical, electrical, optical and pneumatic.  | <b>1</b>     |                             |
|                                   | Angular Measurement – Bevel protractor; Sine Bar, principle and use of sine bar, sine centre; Angle gauges.  | <b>1</b>     |                             |
|                                   | Spirit level; Angle Dekkor; Clinometers.   | <b>1</b>     |                             |
| <b>II</b>                         | Limits and Limit gauges – Making to suit, selective assembly, systems of limits and fits; Types of fits; Hole basis system and Shaft basis system.                   | <b>1</b>     | <b>15%</b>                  |
|                                   | Standard systems of limits and fits; Shaft and Hole system; Tolerance, allowance and deviation (as per BIS).   | <b>1</b>     |                             |
|                                   | Simple problems on tolerance and allowance, shaft and hole system.   | <b>1</b>     |                             |
|                                   | Limit Gauges – GO and NO GO gauges; types of limit gauges.   | <b>1</b>     |                             |
|                                   | Gauge design - Taylor's principle of gauging; Gauge tolerance, disposition of gauge tolerance, wear allowance.   | <b>1</b>     |                             |
|                                   | Optical Measuring Instruments: - Benefits of using light waves as standards; Monochromatic light; Principle of Interference.   | <b>1</b>     |                             |
|                                   | Interference band using optical flat, application in surface measurement.  | <b>1</b>     |                             |
|                                   | Interferometers – NPL flatness interferometer, Pitter-NPL gauge interferometer.  | <b>1</b>     |                             |
| <b>FIRST INTERNAL EXAMINATION</b> |  |              |                             |
|                                   | Screw thread measurement – Screw thread terminology; Measurement of major diameter; Measurement of minor or root diameter.   | <b>1</b>     |                             |
|                                   | Measurement of pitch; Measurement of effective diameter with two wire method and three wire method.  | <b>1</b>     |                             |
|                                   | Measurement of flank angle and form by profile projector and   | <b>1</b>     |                             |

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|------------------------------------|--|----------|------------|
| <b>III</b>                         | microscope.  |          | <b>15%</b> |
|                                    | Measurement of surface texture – Meaning of surface texture, roughness and waviness; Analysis of surface traces, peak to valley height, R.M.S. value, Centre Line Average and $R_a$ value, $R_t$ , $R_z$ etc.              | <b>1</b> |            |
|                                    | Methods of measuring surface roughness – Stylus probe, Tomlinson surface meter, Talysurf; Terms used in surface roughness measurement – assessment length, roughness width cut-off, sampling length and evaluation length. | <b>1</b> |            |
|                                    | Interference method for measuring surface roughness – using optical flat and interferometers.  | <b>1</b> |            |
|                                    | Autocollimator, principle and use of autocollimator.   | <b>1</b> |            |
| <b>IV</b>                          | Machine tool metrology – Alignment testing of machine tools like lathe, milling machine, drilling machine.   | <b>1</b> | <b>15%</b> |
|                                    | Advanced measuring devices – Laser interferometers.  | <b>1</b> |            |
|                                    | Coordinate Measuring Machine (CMM) – Introduction to CMM; Components and construction of CMM.  | <b>1</b> |            |
|                                    | Types of CMM; Advantages and application of CMM  | <b>1</b> |            |
|                                    | CMM probes, types of probes – contact probes and non contact probes  | <b>1</b> |            |
|                                    | Machine Vision – Introduction to machine vision, functions, applications and advantages of machine vision.   | <b>1</b> |            |
|                                    | Steps in machine vision  | <b>1</b> |            |
| <b>SECOND INTERNAL EXAMINATION</b> |  |          |            |
| <b>V</b>                           | Introduction to Mechanical Measurement – significance of mechanical measurement; Fundamental methods of measurement; Classification of measuring instrument.   | <b>1</b> | <b>20%</b> |
|                                    | Stages in generalized measuring system – Sensor-Transducer stage, Signal-Conditioning stage, Readout-Recording stage; Types of input quantities; Active and Passive transducers.   | <b>1</b> |            |
|                                    | Performance characteristic of measuring devices – Static characteristics – Accuracy, Precision, Repeatability, Sensitivity, Reproducibility, Drift, Resolution, Threshold, Hysteresis, Static calibration.                 | <b>1</b> |            |
|                                    | Dynamic characteristics- different order systems and their response-, Measuring lag, Fidelity, Dynamic error; Types of errors in measurement.  | <b>1</b> |            |
|                                    | Transducers – Working, Classification of transducers.  | <b>1</b> |            |
|                                    | Motion and Dimension measurement – LVDT – Principle, applications, advantages and limitations.   | <b>1</b> |            |
| <b>VI</b>                          | Strain and Stress Measurement - Electrical resistance strain gauge - Principle, operation.   | <b>1</b> |            |
|                                    | Measurement of Force and Torque – Strain-Gauge Load Cells, Hydraulic and Pneumatic load cells – basic principle and three component force measurement using piezoelectric quartz crystal.                                  | <b>1</b> |            |
|                                    | Torque Measurement – Dynamometers – Mechanical, Hydraulic and Electrical.  | <b>1</b> |            |
|                                    | Vibration measurement – Vibrometers and Accelerometers – Basic principles and operation.   | <b>1</b> |            |

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|--|----------|------------|
| Temperature Measurement – Use of Thermal Expansion – Liquid-in-glass thermometers, Bimetallic strip thermometer, Pressure thermometers.  | <b>1</b> | <b>20%</b> |
| Thermocouples – Principle, application laws for Thermocouples, Thermocouple materials and construction, measurement of Thermocouple EMF. | <b>1</b> |            |
| Resistance Temperature Detectors (RTD); Thermistors; Pyrometers (Basic Principles).  | <b>1</b> |            |
| <b>END SEMESTER EXAMINATION</b>  |          |            |

### Question Paper Pattern

**Maximum marks: 100**

**Time: 3 hrs**

The question paper should consist of three parts

**Part A**

There should be 2 questions each from module I and II

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part B**

There should be 2 questions each from module III and IV

Each question carries 10 marks

Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

**Part C**

There should be 3 questions each from module V and VI

Each question carries 10 marks

Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.

