DEPARTMENT OF MECHANICAL ENGINEERING
ME8501 METROLOGY AND MEASUREMENTS

UNIT I BASICS OF METROLOGY

Introduction to Metrology – Need – Elements – Work piece, Instruments – Persons – Environment – their effect on Precision and Accuracy – Errors – Errors in Measurements – Types – Control – Types of standards.

PART A

1. What is Range of measurement? (NOV/DEC2015)

The physical variables that are measured between two values. One is the higher calibration value H, and the other is Lower value L, The difference between H, and L, is called range.

2. What is Legal metrology? (MAY/JUNE2014)

Legal metrology is part of Metrology and it is directed by a national organization which is called national service of legal Metrology.

3. Differentiate between sensitivity and range with suitable example? (MAY/JUNE2014)

Example: A Instrument have a scale reading of 0.01mm to 100mm. Here, the sensitivity of the instrument is 0.0lmm i.e. the minimum value in the scale by which the instrument can read. The range is 0.01 to 100mm i.e. the minimum to maximum value by which the instrument can read.

4. Define system error and correction Error? (NOV/DEC2011)

The deviation between the results of measured value to the actual value. Correction: The numerical value which should be added to the measured value to get the correct result.

5. Define: Readability? (NOV/DEC2012)

It is a term frequently used for analog type instruments. This characteristic depends on both the instrument and observer.

6. Define Calibration? (NOV/DEC2014)

Calibration is the process of determining and adjusting an instruments

accuracy to make sure its accuracy is within the manufacturer's specifications

7. What is Hysteresis? (NOV/DEC2004)

All the energy put into the stressed component when loaded is not recovered upon unloading. So, the output of measurement partially depends on input called hysteresis.

8. What is measurement? Give it types? (MAY/JUNE2008)

It is the process of comparing the input signal with predefined standard and it gives out the result. It is a word used to describe about physical quantities such as length, weight, temperature, pressure, force etc

Types

1. Primary measurements
2. Secondary measurements.
3. Tertiary measurements

9. Define the term reliability? (NOV/DEC2008)

Reliability is the ability of a person or system to perform and maintain its functions in routine

circumstances.

10. What is static response? (NOV/DEC2012)

Measured variables are many times steady, that is, they do not vary with time. That is they are static in nature.

11. Differentiate between precision and accuracy? (NOV/DEC2014)

Accuracy - The maximum amount by which the result differ from true value. Precision - Degree of repetitiveness. If an instrument is not precise it will give different results for the same dimension for the repeated readings.

12. Brief on sensitivity in measurement.(NOV/DEC2016)

Sensitivity is an absolute quantity, the smallest absolute amount of change that can be detected by a measurement.

13. Differentiate between accuracy and precision.(NOV/DEC2016)

Accuracy can be defined as the amount of uncertainty in a measurement with respect to an absolute standard.

Precision describes the reproducibility of the measurement. For example, measure a steady state signal many times.

14. Define Traceability. (April/May 2017)

The term "measurement traceability" is used to refer to an unbroken chain of comparisons relating an instrument's measurements to a known standard. Calibration to a traceable standard can be used to determine an instrument's bias, precision, and accuracy.

15. What is difference between gauging and measurements?(April/May 2017)

Gauging is the process of determine the exact dimensions, capacity, quantity, or force of measure.

A **measurement** is a method of determining quantity, capacity, or dimension. Several systems of measurement exist, each one comprising units whose amounts have been arbitrarily set and agreed upon by specific groups.

Part-B & C

1. Define standards. Discuss different type of standards indetail? (APR/MAY 2017)

2. Describe the different types of error in measurement and their causes and control methods in detail? (MAY/JUNE2014) (NOV/DEC2014) (NOV/DEC2016)(APR/MAY 2017)

3. Distinguish between precision and accuracy with illustration?(MAY/JUNE2012) (NOV/DEC2010)

4. List the various measurement methods and explain? (NOV/DEC2008)

5. Draw the block diagram of generalized measurement system and explain different stages with examples. (NOV/DEC2015)

6. Distinguish between and give appropriate examples in each case

(i) Repeatability and Reproducibility (NOV/DEC2014) (ii) Systematic and Random errors (NOV/DEC2006) (iii) Static and Dynamic response (NOV/DEC2006)

UNIT-2 LINEARAND ANGULAR MEASUREMENTS

Linear Measuring Instruments – Evolution – Types – Classification – Limit gauges – gauge design – terminology – procedure – concepts of interchange ability and selective assembly – Angular measuring instruments – Types – Bevel protractor clinometers angle gauges, spirit levels sine bar – Angle alignment telescope – Autocollimator – Applications.

Part-A

1. List any four angular measuring instruments(APRIL/MAY 2016)

- Sinebar
- Bevel protractor
- Autocollimeter
- Angle dekkor

2. Why are sine bars not used for measuring large angles (APR/MAY 2015)

- The sine bar is physically clumsy to hold in position.
- The body of the sine bar obstructs the gauge block stack even if relieved
- Slight errors of the sine bar cause large angular errors

3. State the principle of interferometry. NOV/DEC 2015

Interferometry makes the use of the principle of superposition to combine separate wave together in a way that will cause the result of the combination to have some meaningful property that is diagnostic of the original state of the waves.

4. Classify the comparator according to the principles used for obtaining magnification.

The common types are: (i) Mechanical comparators. (ii) Electrical comparators. (iii) Optical comparators. (iv) Pneumatic comparators. 34. How the mechanical comparator works? The method of magnifying small movement of the indicator in all mechanical comparators are effected by means of levers, gear trains or a combination of these elements.

5. How the mechanical comparator is used?

State with any one example. Let us assume that the required height of the component I s 32.5mm. Initially, this height is built up with slip gauges. The slip gauge blocks are placed under the stem of the dial gauge. The pointer in the dial gauge is adjusted to zero. The slip gauges are removed- Now, the component to be checked is introduced under the stem of the dial gauge. If there is anydeviation in the height of the component, it will be indicated by the pointer.

6. State any four advantages of mechanical comparator. MAY/JUN 2013

It is usually robust, compact and easy to handle.
There is no external supply such as electricity are required.
It has very simple mechanism and is cheaper when compared toother types.
It is suitable for ordinary workshop and also easily portable.

7. Mention any two disadvantages of reed type mechanical comparator.

a) Accuracy of the comparator mainly depends on the accuracy of the rackand pinion arrangement. Any slackness will reduce accuracy.
b) It has more moving parts and hence friction is more and accuracy is less.

8. What are the advantages of electrical and electronic comparator?MAY/JUNE 2014

It has less number of moving parts.

Magnification obtained is very high.

Two or more magnifications are provided in the same instrument to usevarious ranges. The pointer is made very light so that it 'IS more sensitive to vibration.

9. What are the advantages of pneumatic comparator? (APRIL/MAY 2016)

- The wear of measuring heads is avoided due to absence of direct contact.
- Friction is less due to less number of moving parts.
- Work piece is cleaned by supplying of all during the measurement.
- High magnification is possible.
- There is no interference of measuring head and indicating device becausethe measuring head is kept away from the indicating device.

11. Why lasers are used in Metrology?(NOV/DEC 2015)

Intensity of laser can be easily changed.

It helps for high accurate measurement

12. Write any two precautions to be followed when using gauge block. (NOV/DEC 2015)

a) The gauge block surface should be cleaned from dustparticles.
b) Wringing and slipping process should be done beforemeasurement.

13. State the working principle of Electronic comparator.MAY/JUNE2014

In an electronic comparator, transducer or the principle ofapplication of frequency modulation or radio oscillation is followed.

14. Write the constructional requirements of the sine bar for accurate measurement NOV/DEC 2014

(i) The rollers must have equal diameter and equal cylinders
(ii) The rollers should be placed parallel to each other and also to theupper face.
(iii) The accurate center to center of rollers must be known.

15. **Write a short notes on Bevel protractor? (Nov Dec 2016)**

A bevel protractor is a graduated circular protractor with one pivoted arm used for measuring or marking off angles

16. Write short notes on Interchangeability? (Nov Dec 2016)

It refers to Interchangeable parts, the ability to select components for assembly at random and fit them together within proper tolerances.

17. Why is rocking procedure followed when measuring with a dial bore gauge? (April May 2017)

The rocking will first align the gauge with the bore axis and the act of moving the handle to the other side of the bore will bring it to the exact borediameter.

18. Name any four instruments used measuring internal diameters in components. (April May 2017)

- Inside Micrometer
- Bore Gauge
- Caliper Type Inside Micrometer
- Vernier Caliber

PART-B

1. Give a brief note on slip gauges and what are the safety precaution tobe followed in the use of slip gauge blocks and also explain the type of limit gauge with neat sketches (APRIL /MAY 2015) ?(NOV/DEC2016)

2. Explain the construction and working of vernier caliper. Enumerate the different types of vernier caliper with neat sketches also explain the construction and working of micrometers. Enumerate the micrometer with neat sketches . (APRIL/MAY 2015)

3. Explain the working principle of mechanical comparator ,optical comparator and Pneumatic comparator with neat sketches (MAY/JUNE 2014)

4. Explain the working principle of angle Dekkor with a neat sketch. Also write the applications of angle Dekkor. And also explain how the measurements are made in optical bevel protractor. (NOV/DEC2014 & 2015,2016)

5. Explain the working principle of autocollimator and briefly explain itsapplication. NOV/DEC 2010,(APR/MAY 2017)

6. Explain the working principle of SINE BAR (APR/MAY 2017)

UNIT 3- ADVANCES IN METROLOGY

Basic concept of lasers Advantages of lasers — laser Interferometers — types — DC and AC Lasers interferometer — Applications — Straightness — Alignment. Basic concept of CMM — Types of CMM — Constructional features — Probes — Accessories — Software — Applications — Basic concepts of Machine Vision System — Element — Applications.

Part-A

1. **Why is laser preferred in engineering metrology? (Nov 10)**

   It has high precision , accuracy , rapid non contact of gauging of soft,delicate or hot moving points.

2. **Write the application of laser interferometer? (Nov 12)**

   Laser measurement and angular measurement.

3. **List the various geometrical checks made on machine tools. (MAY 2014)**

   Straightness of guide ways and slide ways of machine tool.

   Flatness of machine tables and slide ways.

   Parallelism, equidistance and alignment of the slide ways.

   True running and alignment of shaft and spindle.

   The pitch error or lead of lead screw.

   Pitch errors of gears.

4. **Define straightness of axes? (Nov 13)**

It is defined as the deviation from a straight line in two orthogonal planes for each axis movement and six measurements to be considered. Straight lines of x-axis are measured in y and z direction. Y-axis in x and z direction. Z-axis in x and y direction.

5. **What are the benefits of using CMM? (** Nov 14)

Data communication

Digital input and output comment Minimize CNC programInterface to CAD software.

6. **Write some features of CMM software. (NOV/DEC 2015)**

Measurement of diameter, center distance can be measured as follows: 1. Measurement of plane and spatial curves 2. Minimize CNC programme. 3. Data communications. 4. Digital input and output command 5. Interface to CAD software.

7. **Define machine vision.(May'14)**

Machine vision can be defined as a means of simulating the image recognition and analysis capabilities of the human system with electronic andelectromechanical techniques.

8. **What are the four basic types of machine, vision system?**

Image formation.

Processing of image.

Analyzing the image
Interpretation of image.

9. **Write the advantages of CMM. (NOV/DEC 2013)**

Quicker inspection
Accurate measurements
Easier to position
More accurate

10. **What are advantages of laser interferometer. (NOV/DEC 2014)**

Suited for measuring linear positioning, straightness in to twoplanes
Long covering range and high sensitivity
Free from noise disturbance
Non-contact measurement is possible

11. **Differentiate between straightness and flatness. (April/May2016)**

Straightness is defined as a line where all elements of a line are collinear but flatness is the minimum distance between two planes within all points on asurface.

12. What is diffraction grating. (Nov/Dec2015)

Diffraction grating is an optical component with a periodic structure, whichsplits and diffracts light into several beams travelling in different directions.

13. Differentiate between Rt and Rz. (April/May 2015)

Stylus (X, Y) Rt, the Maximum Profile Height Along (X,Y), is determined from the difference between the highest peak and lowest valley found along the evaluation length.

Stylus (X,Y) Rz, the Average Maximum Profile Height Along (X,Y), isderived from the average, over all cutoff lengths (i.e. sampling lengths), of the difference between the highest peak and lowest valley.

14. Why laser is used as light source in interferometers?(Nov Dec 2016)

Laser is used as light source in interferometers because Laser light has four unique characteristics that differentiate it from ordinary light: these are

Coherence
Directionality
Monochromatic
High intensity

15. Name the different stages involved in the machine vision based measurement.(Nov Dec 2016)

Image Acquisition

Image Processing or Image Enhancement

Image Segmentation

Image Analysis

Model Matching or Pattern Recognition

16. What is mean by "Qualifying the Tip" in CMMs?(April May 2017)

Tip Qualification uses the tip estimate to determine whether the tip is acceptable for use. This feature can be used to check tips periodically for signs of wear, and to exchange unacceptably worn tips. By using tip qualification to enforce tip acceptance criteria, metrological values can be compared from image to image, ensuring consistent, long-term comparability of samples.

Part-B

1. Explain the construction and working of a laser telemetric systemwith a neat sketch. (NOV/DEC 2012)

2. Explain the working of AC laser interferometer? (NOV/DEC 2014,2016,2017)

3. Explain the working principle of a Michelson Interferometer with a neat sketch. (NOV/DEC

2015)

4. Discuss the need, types and constructional features of coordinate measuring machine. (NOV/DEC 2013,2016)

5. Define machine vision. Name the four types of machine visionsystem (NOV/DEC 2015)

6. Explain the working of DC laser interferometer? (NOV/DEC 2015)

UNIT 4
FORM MEASUREMENT

Principles and Methods of straightness — Flatness measurement — Thread measurement, gear measurement, surface finish measurement, Roundness measurement — Applications.

Part-A

1. Mention the purpose of Goniometric heads in tool makers microscope? (May 12)

Goniometric head in tool makers microscope is used to measure circular divisions .for example, the flank angle of the gears may be measured using Tool makers microscope with a goniometric head.

2. What is meant by 'Best size wire' in screw thread measurement?(May 16)

Best size of wire is a wire of such diameter that it makes contact with flanks of the thread on the pitch line.

3. What are the factors affecting surface roughness?(May 16,Nov 16)

(a) Vibration
(b) Material of the work piece
(c) Tool (d)Machining

type.

4. Define degree of fullness and degree of emptiness in form factor.(Dec 13)

Degree of fullness is the ratio of area of metal considered to the area of enveloping the rectangle.

Degree of emptiness is the ratio between the difference of the area of metalconsidered to the area of enveloping the rectangle and area of enveloping the rectangle.

5. Define straightness of line in two planes?(MAY/JUNE 14)

A line is said to be straight over a given length of the variation of the distance of its points from two planes perpendicular to each other and parallel to the direction of a line remaining within the specified tolerance limits.

6. Define roundness and name the four measurements of roundness?(Dec14)

It is a surface of the revolution where all surfaces are inserted by any planeperpendicular to a common axis in case of cylinder and cone.

a. Heart square circle

b. Minimum radial separation circle
c. Maximum inscribed circle
d. Minimum circumscribed circle.

7. What is gear run out?(Dec 12)

It means eccentricity in the pitch circle. It will produce periodic vibration duringeach revolution of the gear. It will give the tooth failure in gears.

8. List the reasons for the occurrence of progressive pitch errors in screwthreads? (Dec 12)

a. In correct linear and angular velocity ratio
b. In correct gear train and lead screw
c. Saddle fault

9. Define Lead?(Dec 13)

It is defined as the distance at which a thread advances for onerotation.

Lead=No. of starts ×Pitch

10. Define lead angle?(Dec 13)

It is the angle between the tangent to the helix and plane perpendicular tothe axis of cylinder.

11. What are the various methods used for measuring the gear tooththickness?(May 14)

a. Gear tooth vernier
b. Constant chord method
c. Base tangent method
d. Measurement over pins.

12. Define constant chord?(May 12)

Constant chord is the chord joining points or opposite faces of the tooth.

13. Define straightness of a line in two planes?(May 14)

A line is said to be straight over a given length of the variation of the distance of its points from two planes perpendicular to each other and parallel to the direction of a line remaining within the specified tolerance limits.

14. Define drunken thread

A condition in which the crest of a thread or threads wavers or is uneven

15. What are the various factors affecting surface roughness of the machined components?

- Vibration of the machine tool
- In proper clamping of work piece
- Over depth of cut /feed rate

16. Is assessment length greater/ lesser than traverse length in surface finish measurement? Why?

The assessment length or evaluation length is the length of data that will be used for

analysis. Commonly one sampling length is discarded from each end of the measurement length.

The measurement length is dictated by the numerical value of the cut-off, which itself is dictated by the type of surface inspection.Typically, a measurementmay consist of a traverse of 6-7 times the cut-off selected. For example, 7 cut-offs at 0.8mm = 5.6mm. One of two cut-offs will then be removed according to the filter type and the remaining cut-offs used for assessment. This only applies whenmeasuring roughness.

17. Write any 4 applications of artificial vision systems in manufacturing industries.(April May 2017)

Automatic inspection, e.g., in manufacturing applications;

Assisting humans in identification tasks, e.g., a species identificationsystem

Controlling processes, e.g., an industrial robot;

Navigation, e.g., by an autonomous vehicle or mobile robot; and

Part-B

1. Explain in detail the various methods used for checking the profile of aspur gear Profile checking.

2. Explain in detail the various methods used to measure the pitch of a spur gear

3. Explain how straightness is measured using the following instruments

4. Explain the following direct methods of surface finish measurements.(NOV/DEC 2015)

5.Explain the tooth thickness measurement for the following methods(APRIL/MAY 2016,2017)(NOV/DEC2016)

6. Explain the following methods to measure the major, minor andeffective diameter of a screw thread.

7. Explain the various methods by which roundness is measured.(NOV/DEC2014,2016)

UNIT 5

MEASUREMENT OF POWER, FLOW AND TEMPERATUREPART

Force, torque, power — mechanical , Pneumatic, Hydraulic and Electrical type. Flow measurement: Venturimeter, Orifice meter, rotameter, pitot tube — Temperature: bimetallic strip, thermocouples, electrical resistance thermometer — Reliability and Calibration — Readability and Reliability.

PART A

1. Why are measuring instruments calibrated? [Nov/Dec 2015]

Calibration is a comparison between a known measurement (the standard) and the measurement using your instrument. Typically, the accuracy of the standard should be ten times

the accuracy of the measuring device being tested. The accuracy of all measuring devices degrade over time. This is typically caused by normal wear and tear. However, changes in accuracy can also be caused by electric or mechanical shock or a hazardous manufacturing environment (e.x., oils, metal chips etc.). Depending on the type of the instrument and the environment in which it is being used, it may degrade very quickly or over a long period of time. The bottom line is that, calibration improves the accuracy of the measuring device. Accurate measuring devices improve product quality.

2. What is the working principle behind strain gauges? [Nov/Dec 2015]

Each metal has its specific resistance. An external tensile force /(compressive force) increases/decreases the resistance by elongating/contracting it. Suppose the original resistance is R and a strain initiated change in resistance is ΔR. Then, the following relation is concluded:

$$\frac{\Delta R}{R} = Ks \cdot \frac{\Delta L}{L} = Ks \cdot \varepsilon$$

where, Ks is a gauge factor, the coefficient expressing strain gauge sensitivity. General purpose strain gauges use copper-nickel or nickel-chrome alloy for the resistive element, and the gauge factor provided by these alloys are approximately 2.

3. What are load cells? [May/June 2016]

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various types of load cells include hydraulic load cells, pneumatic load cells and strain gauge load cells. Strain gauge load cells are the most common in industry. These loadcells are particularly stiff, have very good resonance values, and tend to have long life cycles in application. Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress and/or strain that the material load cell is undergoing at the time. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

4. Mention the principle involved in bimetallic strip. [May/June 2016]

Bimetallic strip thermometers are mechanical thermometers. They are widely used in industry for temperature control because of their robustness,temperature range and simplicity. It consists of two strips made of dissimilar metals and bonded together with one end fixed and the other free.

A bimetallic strip is used to convert a temperature change into mechanical displacement. The strip consists of two strips of different metals which expand at different rates

as they are heated, usually steel and copper, or in some cases steel and brass. The strips are joined together throughout their lengthby riveting, brazing or welding. The different expansions force the flat strip to bend one way if heated, and in the opposite direction if cooled below its initial temperature. The metal with the higher coefficient of thermal expansionis on the outer side of the curve when the strip is heated and on the inner side when cooled.

5. What is the working principle of thermocouple?

The basic principle is "when two dissimilar metals are joined together an emf will exist between the two points A and B which is primarily a function of the junction temperature. The above said to be principle is Seeback effect.

6. Define the principles of electrical resistance thermistor. [Apr/ May 2013]

The basic principle involved in thermistor is when it is subjected to a temperature change, the esistance of the thermistor changes. This change in resistance will be the increase in temperature.

7. List any two methods employed for measuring torque. [Nov/Dec 2012]

Torque reaction methods
Proney brake
Torque measurement using strain gauges
Torque measurement using torsion bars

8. Differentiate between primary and secondary transducers. [Apr/May 2012]

S.No	**Primary transducer**	**Secondary transducer**
1.	It is a mechanical device	It is an electrical device
2.	It converts a physical signal into mechanical signal	It converts analog output into electrical signal
3.	Ex. Thermister and thermocouples.	Ex. Accelerometer and Piezoelectric transducer.

9. Give the principle of hot wire anemometer. [Apr/ May 2014]

An anemometer is a device for measuring mean and fluctuating velocities in fluid flows. The reduction of temperature of a surface resulting from the heat transferred owing to the fluid flow is related to flow rate.

10. Give the classification of temperature measuring instruments. [Apr/May 2012]

i) Gas filled temperature measurement
ii) Electrical resistance temperature measurement
iii) Thermocouple temperature measurement
iv) Semiconductor based temperature measurement

11. Give the principle of hot wire anemometer.(Nov Dec 2016)

Hot wire anemometers use a very fine wire electrically heated tosome temperature above the ambient. Air flowing past the wire cools the wire. As the electrical resistance of most metals is dependent upon the temperature of the metal, a relationship can be obtained between

the resistance of the wire and the flow speed.

12. Name the materials used for thermocouples.(Nov Dec 2016)

- Nickel-alloy
- Platinum/rhodium-alloy
- Tungsten/rhenium-alloy
- Chromel–gold/iron-alloy

13. What is meant by reliability of a measuring instrument?(April may 2017)

Instrument reliability is a way of ensuring that any instrument used for measuring experimental variables gives the same results every time.

14. Write the working principle of pyrometer.(April may 2017)

A pyrometer is a type of remote-sensing thermometer used to measure the temperature of a surface.The main working principle of this type of instruments is that, it senses the heat radiation from a targeted hot body and readsand records its temperature, depending upon the intensity of radiation.

PART B

1. With a neat diagram explain the working of bimetallic strip. [Nov/Dec 2015]
2. With a neat diagram explain the working of rotometer. [Nov/Dec 2015,2016]
3. Explain the working of orificemeter with neat sketch. [May/june 2016]
4. Explain the working of venturimeter with neat sketch. [May/june2016]
5. 5. Explain the working of Electrical resistance thermometer (NOV/DEC2016)
6. With a neat diagram explain the working of Optical pyrometer. [Nov/Dec2015]
7. Discuss the working principle of bourdon tube pressure gauge
8. With neat diagram discuss the working of liquid in glass thermometer
9. With neat diagram explain the construction and working principle of pitot tube.