

METROLOGY & MEASUREMENTS

UNIT-I-ConceptOfMeasurment

TWOMARKQUESTIONSANDANSWERS

1. What is Range of measurement?:

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 Resolution:

The minimum value of the input signal is required to cause an appreciable change in the output known as resolution.

3. Differentiate between sensitivity and range with suitable example. Example: An instrument has a scale reading of 0.01mm to 100mm.

Here, the sensitivity of the instrument is 0.01mm 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: 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: Measurand.

Measurand is the physical quantity or property like length, diameter, and angle to be measured.

6. Define: Deterministic Metrology.

The metrology in which part measurement is replaced by process measurement. The new techniques such as 3D error compensation by CNC systems are applied.

7. Give any four methods of measurement

1. Direct method.
2. Indirect method.
3. Comparison method.
4. Coincidence method.

8. Give classification of measuring instruments.

1. Angle measuring Instruments.
2. Length measuring Instruments.
3. Instruments for surface finish.
4. Instruments for deviations.

10. Define True size:

True size is Theoretical size of a dimension

11. Define Actual size

Actual size = Size obtained through measurement with permissible error.

12. What is Hysteresis

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

13. Differentiate accuracy and Uncertainty with example.

Accuracy – Closeness to the true value.

Example: Measuring accuracy is $\pm 0.02\text{mm}$ for diameter 25mm. Here the measurement true values lie between 24.98 to 25.02mm. Uncertainty about the true value $= \pm 0.02\text{mm}$

14. Define Span :

The algebraic difference between higher calibration values to lower calibration value.

Example: In a measurement of temperature higher value is 200°C and lower value is 150°C $\text{span} = 200 - 150 = 50^\circ\text{C}$

15 Differentiate between precision and accuracy.

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.

16. What is Scale interval:

It is the difference between two successive scale marks in units.

17. What is Response time:

The time at which the instrument begins its response for a change measured quantity.

18. Explain the term magnification :

It means the magnitude of output signal of measuring instrument times increases to make it more readable

19. Classify the Absolute error.

The absolute error is classified into 1. True absolute error 2. Apparent absolute error

20. What is Relative error.

Relative error is defined as the results of the absolute error and the, value of comparison used for calibration. It is commonly denoted as error arithmetic mean for series of measurement.

21. Classify the errors

The errors can be classified into

1. Static errors-Reading errors
 - Characteristic errors,
 - Environmental errors
2. Loading errors
3. Dynamic error

22. What are the applications of Legal metrology?

1. Industrial
2. Commercial transactions
3. Public health and human safety ensuring.

24. What is the need of inspection

To determine the fitness of new made materials, products or component part and to compare the material with the established standard.

25. What are the important elements of measurements?

1. Measurand
2. Reference
3. Comparator

26. What is LEGAL METROLOGY

Legal metrology is part of Metrology and it is directed by a National Organisation which is called "National service of Legal Metrology". The main objective is to, maintain uniformity of measurement in a particular country.

UNIT II – Linear and Angular Measurements

27. What are the considerations while manufacturing the slip gauges?

The following additional operations are carried out to obtain the necessary qualities in slip gauges during manufacture.

1. First the approximate size of slip gauges is done by preliminary operations.
2. The blocks are hardened and wear resistant by a special heat treatment process.
3. To stabilize the whole life of blocks, seasoning process is done.
4. The approximate required dimension is done by a final grinding process.

28. How do you calibrate the slip

gauges? Comparators are used to calibrate the slip gauges.

29. List the various linear measurements?

- (i) Length
- (ii) Heights and
- (iii) Thickness

30. What are the various types of linear measuring instruments?

The various devices used for measuring the linear measurements are

- i. Vernier calipers
- ii. Micrometers
- iii. Slip gauge or gauge blocks
- iv. Comparator

31. List out any four angular measuring instrument used in metrology

- (i) Angle gauges
- (ii) Divided scales
- (iii) Sine bar with slip gauges
- (iv) Auto collimator
- (v) Angle divider

32. What is comparators?

Comparators are one form of linear measurement device which is quick and more convenient for checking large number of identical dimensions.

33. 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 done by means of levers, gear trains or a combination of these elements.

35. State the best example of a mechanical comparator.

A dial indicator or dial gauge is used as a mechanical comparator.

36. Define least count and mention the least count of a mechanical comparator.

Least count. - The least value that can be measured by using any measuring instrument known as least count. Least count of a mechanical comparator is 0.01 mm

37. How the mechanical comparator is used? State with any one example.

Let us assume that the required height of the component is 32.5 mm. Initially, this height is built up with slip gauges. The slip gauge blocks are placed under the stem of the dial gauge. The pointer indicates the height of the slip gauges. Now the component to be checked is introduced under the stem of the dial gauge. If there is any deviation in the height of the component it will be indicated by the pointer.

38. State any four advantages of reed type mechanical comparator.

- (i) It is usually robust, compact and easy to handle. It has very simple mechanism and is cheaper when compared to other types.
- (ii) It is suitable for ordinary workshop and also easily portable.

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

- (i) Accuracy of the comparator mainly depends on the accuracy of the rack and pinion gear. Any slackness will reduce accuracy.
- (ii) It has more moving parts and hence friction is more and accuracy is less.

40. What are the major types of an electrical comparator?

An electrical comparator consists of the following three major parts such as

- (i) Transducer
- (ii) Display device as meter
- (iii) Amplifier

41. On what basis the transducer works?

An iron armature is provided in between two coils held by a leaf spring at one end. The other end is supported against a plunger. The two coils act as two arms of an A.C. wheatstone bridge circuit.

42. How is the accuracy of an electrical comparator checked?

To check the accuracy of a given specimen or work, first a standard specimen is placed under the plunger. After this, the resistance of wheat stone bridge is adjusted that the scale reading shows zero. Then the specimen is removed. Now, the work is introduced under the plunger.

43. State the working principle of an electronic comparator.

In electronic comparator, transducer induction or the principle of application of frequency ~~mult~~ radio oscillation is followed.

44. Mention the important parts of an electronic comparator.

(i) Transducer (ii) Oscillator (iii) Amplifier (iv) Demodulator (v) Meter

45. Classify pneumatic comparators.

(i) Flow or Velocity type. (ii) Back pressure type

46. What are the advantages of electrical and electronic comparator?

- (i) It has less number of moving parts.
- (ii) Magnification obtained is very high.
- (iii) Two or more magnifications are provided in the same instrument to use various ~~ngs~~
- (iv) The pointer is made very light so that it is more sensitive to vibration.

47. What are the disadvantages of electrical and electronic comparator?

- (i) External agency is required to metre for actuation.
- (ii) Variation of voltage or frequency may affect the accuracy of output.
- (iii) Due to heating coils, the accuracy decreases.
- (iv) It is more expensive than mechanical comparator.

48. List the various parts of an optical comparator

The optical comparator consists of the following parts such as

- (i) Pivoted lever.
- (ii) Objective lens
- (iii) Scale
- (iv) Plunger
- (v) Table and
- (vi) Base.

48. What are the advantages of pneumatic comparator?

- (i) The wear of measuring heads is avoided due to absence of direct contact.
- (ii) Friction is less due to less number of moving parts.
- (iii) Work piece is cleaned by supplying of air during the measurement. ~~(iv) Th~~ magnification is possible.
- (v) There is no interference of measuring head and indicating device because the measuring head is ~~kn~~ away from the indicating device.
- (vi) It is a suitable method to check ovality and taperness of circular bore.

Unit 3 Form Measurement

49. Name the various types of pitch errors found in screw?

- (i) Progressive error (ii) Drunken error (iii) Periodic error (iv) Irregular errors.

50. Name the various methods of measuring the minor diameter of the thread.

51. Name the various methods used for measuring the major diameter

- (i) Ordinary micrometer (ii) Bench micrometer

52. Name the various methods for measuring effective diameter.

- (i) One wire method (ii) Two wire method (iii) Three wire method.

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53. Name the various methods for measuring pitch diameter.

- (i) Pitch measuring machine (ii) Tool makers microscope (iii) Screw pitch gauge.

54. Name the two corrections are to be applied in the measurement of effective diameter. ~~the~~

- (i) Compression correction,

55. What is best size of wire?
Best size of wire is a wire of such diameter that it makes contact with the flanks of the thread on the pitch line.
56. Define. Drunken thread
This is one, having erratic pitch, in which the advance of the helix is irregular in one complete revolution of thread.
57. What is the effect of flank angle error?
Errors in the flank cause a virtual increase in the effective diameter of a bolt and decrease in that of nut.
58. What are the applications of toolmaker's microscope?
(i) Linear measurement (ii) Measurement of pitch of the screw (iii) Measurement of thread angle
59. Define: Periodic error.
The periodic error repeats itself at equal intervals along the thread.
60. What are the commonly used forms of gear teeth?
(1) Involute (ii) Cycloidal
61. What are the types of gears?
(i) Spur (ii) Helical (iii) Bevel (iv) Worm wheel (v) Rack and pinion.
62. Define: Module
Module = pitch circle diameter / number of teeth
63. Define: Lead angle
It is the angle between the tangent to the helix and plane perpendicular to the axis of cylinder.
64. What are the various methods used for measuring the gear tooth thickness?
(i) Gear tooth vernier (ii) Constant chord method (iii) Base tangent method (iv) Measurement on pins
65. Name four gear errors.
(i) Pitch error (ii) Alignment error (iii) Composite error (iv) Thickness error
66. Name the method used for checking the pitch of the gear.
(i) Step by step method. (ii) Direct angular measurement.
67. What are the direct angular measurements methods?
1. Profile checking: a) Optical projection method b) Involute measuring method.
2. Thickness measurement: a) Chordal thickness method b) Constant chord method.
68. Define: constant chord
Constant chord is the chord joining those points, or opposite areas of the tooth.

69. Give the formula for measuring radius of circle.

$$R = \frac{(I - d)^2}{8d}$$

Where, R=Radius of the job I=Distance between the balls d=Diameter of pins.

70. What are the two methods used in measuring radius of concave surface.

a) Edges are well defined. b) Edges are rounded up.

71. What are the factors affecting surface roughness?

a) Vibrations b) Material of the workpiece c) Tool d) Machining type

72. What are the methods used for evaluating the surface finish?

a) Peak to valley height method. b) The average roughness method. c) Form factor method.

73. Define fullness and emptiness in form factor.

Degree of fullness (K) = $\frac{\text{area of metal}}{\text{Area of enveloping rectangle}}$
Degree of emptiness = 1 - K

74. What are the methods used for measuring surface roughness?

a) Inspection by comparison b) Direct instrument measurements.

75. What are the stylus probe instruments?

a) Profilometer b) Taylor Hobson Talysurf c) Tomlinson surfacemeter

76. Define: Straightness of a line in two planes.

A line is said to be straight over a given length, if the variation of the distance of its points from a straight line is within the specified tolerance limits.

77. Define: Roundness. Name the four measurement of roundness.

It is a surface of revolution where all the surfaces intersected by any plane perpendicular 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.

78. Name the devices used for measurement of roundness.

1. Diametral 2. Circumferential confining gauge. 3. Rotating on center.
4. V-Block 5. Three point probe 6. Accurate spindle.

79. Define: Lay

Lay: - Direction of the 'predominate surface pattern'

80. What is runout?

Runout: - Total range of reading of a fixed indicator with the contact points applied to a surface without axial movement, about 3 fixed axis.

UNIT 4 - Laser and advances in Metrology

81. What is interferometer?

Interferometer is optical instruments used for measuring flatness and determining the lengths of slip gauges by direct reference to the wave length of light.

82. Name the different types of interferometer?

1) NPL flatness interferometer 2) Michelson interferometer
3) Laser interferometer 4) Zernike gauge block interferometer.

83. Name the common source of light used for interferometer

a. Mercury 198 b. Cadmium c. Krypton 86 d. Helium e. Hydrogen

84. What is meant by alignment test on machine tools?

The alignment test is carried out to check the grade of manufacturing accuracy of the machine tool

85. List the various geometrical checks made on machine tools.

- a. Straightness of guide ways and slide ways of machine tool.
- b. Flatness of machine tables and slide ways.
- c. Parallelism, equidistance and alignment of the slide ways.
- d. True running and alignment of shaft and spindle.
- e. The pitch error or lead of leadscrew.
- f. Pitch errors of gears.

86. Distinguish between geometrical test and practical test on a machine tool

The alignment test is carried out to check the grade of manufacturing accuracy of the machine tool. Performance test consist of checking the accuracy of the finished component. Alignment test consist of checking the relationship between various machine elements when the machine tool is idle. Performance test is for checking the accuracy of the jobs produced.

87. What are the main spindle errors?

- a) Out of round. b) Eccentricity c) Radial throw of an axis. d) Runout e) Periodical axial slip

88. Write the various tests conducted on any machine tools

1. Test for level of installation of machine tool in horizontal and vertical planes.
2. Test for flatness of machine bed and for straightness and parallelism of bed ways on bearing surface
3. Test for perpendicularity of guide ways to other guide ways.
4. Test for true running of the main spindle and its axial movements.

89. Why the laser is used in alignment testing?

The alignment tests can be carried out over greater distances and to a greater degree of accuracy using laser equipment. The laser beam provides a, imaginary line that can not be seen in space.

90. Classify the machine tool test.

It can be classified into 1. Static tests 2. Dynamic tests.

91. What are the different types of geometrical tests conducted on machine tools?

1. Straightness., 2. Flatness., 3. Parallelism, equi-distance and coincidence.

92. What is CMM?

It is a three dimensional measurements for various components. These machines have precise movement is x,y,z coordinates which can be easily controlled and measured. Each slide in three directions is equipped with a precision linear measurement transducer which gives digital display and

93. Define axial length measuring accuracy

it is defined as difference between the reference length of gauges aligned with a machine axis and the corresponding measurement results from the machine.

94. Write the types of coordinate measuring machines

1. Bridge type
2. Horizontal bore mill
3. Vertical bore mill
4. Spherical coordinate measuring machine

98. Explain CNC, CMM briefly.

A computer numerical control system can be used with CN4M to do calculations while measuring complex parts. Error can be stored in memory while doing calculations. For automatic calibration of probe, determination of co-ordinate system, calculation, evaluation and recording etc., special software's are incorporated.

99. Define machine vision.

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

99. What are the four basic types of machine vision system?

- (i) Image formation.
- (ii) Processing of image.
- (iii) Analyzing the image
- (iv) Interpretation of image.

100. Write the advantages of machine vision system.

- (i) Reduction of tooling and fixture cash.
- (ii) Elimination of need for precise part location.
- (iii) Integrated automation of dimensional
- (iv) Defect detection.

101. Define gray scale analysis.

In these techniques, discrete areas or windows are formed around only the portions of the image to be inspected. For determining a part, this type of analysis is a powerful tool and can be used for inspection of absence, correct part assembly, orientation, part integrity, etc.

104. Mention the advantages of CMM.

- (i) The inspection rate is increased.
- (ii) Accuracy is reduced.
- (iii) Operator's error can be minimized. Skill of the operator is reduced.
- (iv) Reduction in calculating, recording and setup time.
- (v) No need of GO/NOGO gauges.
- (vi) Reduction of scrap and good part rejection.

105. Mention the disadvantages of CMM.

- (i) The table and probe may not be in perfect alignment.
- (ii) The stylus may have runout.
- (iii) The stylus moving in z-axis may have some perpendicularity errors.
- (iv) Stylus while moving in x and y direction may not be square to each other.
- (v) There may be errors in digital system.

106. Mention the application of CMM.

- (i) CMM's to find application in automobile, machine tool, electronics, space and many other large companies.
- (ii) These are best suited for the test and inspection of test equipment, gauges and tools.
- (iii) For aircraft and space vehicles of hundred Percent inspections is carried out by using CMM. CMM can be used for determining dimensional accuracy of the component.
- (v) CMM can also be used for sorting tasks to achieve optimum packing of components within tolerance limits.

107. Describe the features of a flexible inspection system.

- (i) A powerful computer serves as a real time processor to handle part dimensional data and as a multi programming system to perform such tasks as manufacturing process control.
- (ii) The terminal provides interactive communication with personnel Computer where the programmes are stored.
- (iii) Input devices micro process or based gauges and other inspection devices are used in CMM.

108. Write brief note about (i) Co-ordinate measuring machine equipped with a laser probe(ii)Virtual measuring system

(i) A CMM equipped with a laser probe can convert a part of physical model into a digitize file. Such a file can be used to manufacture parts by digital manufacturing. Manufactures can verify that each finished part measures exactly as designed.

(ii) Virtual measuring System uses a microscope system to examine an electronic replica of the Surface texture of part. Surface texture is measured by digitizing of the surface. The images are processed on a PC using vertical scanning interferometry and vision analysis software to produce 2D-profile, 3-D plots and counter plots.

It generates statistics for average roughness, average profile height, reduced peak height, average roughness depth, reduced valley depth and a number of other parameters. It also determines the depth, spacing and angle of the surface texture. It can also be used to measure the surface texture of a cylinder vertically along the cylinder wall.

109. Explain briefly the three important fields of machine vision system

Inspection: It is the ability of an automated vision system to recognize well-defined pattern and if these pattern match the stored in the system makes machine vision ideal for inspection of raw materials, parts, assemblies etc.

Part identification: It is the ability of part recognition provides positive identifications of an object for identification purposes.

Guidance and Control: Machine vision systems are used to provide sensor feed back for real time guidance.

UNIT 5 – Measurement of Power, Flow and Temperature related properties

110. What are load cells?

Are devices for the measurement of force through indirect methods.

111. Give the principle of hot wire anemometer

When a fluid flows over a heated surface heat is transferred from the surface and so the temperature reduces. The rate of reduction of temperature is related to flow rate.

112. State any four inferential type of flow meters

Venturimeter, orifice meter, rotometer, pitot tube.

113. What is the principle involved in fluid expansion thermometer?

Change in pressure in the bulb is taken as an indication of the temperature.

114. Mention the principle involved in bimetallic strip. Is

based on change in dimension

115. What is thermo couple?

When two metals are joined together it will create an emf and it is primarily a function of the junction temperature.

116. What is a Kentometer?

It is a device for measurement of absolute pressure.