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

Introduction to Metrology

1. Define- metrology? [Nov/Dec-06]

Metrology is defined as the "science of measurement". The most important parameter in metrology is the length. Metrology is divided into industrial metrology and medical metrology under consideration of its application and may be divided into metrology of length and metrology of time under consideration of its quantity.

2. Define: Measurand.[Nov/Dec-09]

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

3. What is legal metrology? [May/June-2014]

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

4. What are the applications of Legal metrology?

Applications of Legal metrology:

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

5. Give any four methods of measurement.

Four methods of measurement:

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

6. Give classification of measuring instruments.

Classification of measuring instrument:

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

7. Define: Deterministic Metrology.

Deterministic metrology is defined as the part of measurement is replaced by the process of measurement. The new techniques such as 3D error compensation by CNC systems are applied.

8. What is the basic Principle of measurement?

It is the physical phenomenon utilized in the measurement. If energy kind of quantity measured, there must be a unit to measure it. So this will give the quantity to be measured in number of that unit.

Needs of Metrology

9. What is the need for metrology?

- To determine the true dimensions of a part.
- To increase our knowledge and understanding of the world.
- To ensure public health and human safety.
- To convert physical parameter in to meaningful numbers.

Elements (Work piece, Instruments, Person) and their effect on Precision and Accuracy

10. What are the important elements of measurements? [Nov/Dec-2018]

1) Measuring Instruments
2) Calibration Standards
3) Work piece
4) Person who is carrying out the measurement
5) Environment

11. What are the elements of generalized measurement system?

The generalized measuring systems consist of the following common elements:

1. Primary sensing element
2. Variable conversion element
3. Variable manipulation element
4. Data transmission element
5. Data processing element
6. Data presentation element

12. Differentiate between precision and accuracy. [Nov/Dec-2016] [Nov/Dec-2020]

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.

Errors

13. Define error.

The deviation of the true value form the desired value is called error.

Errors in Measurements

14. What is mean by error in measurement?

Error is the difference between the measured value and true value.

Errors in Measurements= measured value-true value

The errors in measurement can be expressed either as an absolute error or a relative error.

Types of Errors

15. Classify the errors.

The errors can be classified into

1. Static errors

(a)Reading errors

(b) Characteristic errors

(c) Environmental errors

2. Loading errors

3. Dynamic error

16. Define static and dynamic characteristics (static and dynamic response) of a measuring instrument. [Nov/Dec-2013]

Static response: The static characteristics of an instrument are considered for instruments which are used to measure an unvarying process conditions.

Dynamic response: The behaviors of an instrument under such time varying input – output conditions called dynamic response of an instrument. The instrument analysis of such dynamic response is called dynamic analysis of the measurement system.

17. Define systematic errors. [Dec-05]

The systematic are constant and similar in form. These are controllable in both their sense and magnitude. The systematic errors are easily determined and reduced. Hence these are also called as controllable errors.

18. Define system error and correction? [Dec.'09]

Error: The deviation between the results of measured value to the actual value.

Correction: Correction is defined as a value which is added algebraically to the uncorrected result of the measurement to compensate for an assumed systematic error.

19. Classify the Absolute error.

The absolute error is classified into

1. True absolute error, 2. Apparent absolute error.

20. Distinguish between relative error and random error. (Nov.'07)

a) Relative error: Relative error is defined as the results of the absolute error and the value of comparison used for calculation of that absolute error. The comparison may be true value or conventional true value or arithmetic mean for series of measurement.

b) Random errors: This type of errors occurs randomly and reason for this type of errors cannot be specified.

21. What are the various sources of error? (Dec.'08)

- Physical nature of components.
- Linearity, repeatability, hysteresis and resolution.
- Interpolation.
- Environmental condition.
- Loading
- Time variation in measurand.
- Calibration.

22. Mention the various methods used for limiting temperature errors.[Nov.'04]

- Minimization through careful selection of materials and operating temperature ranges.
- Compensation through balancing of inversely reacting elements or effects.
- Elimination through temperature control.

Control (Sensitivity, Range, Repeatability, Reliability, Readability)

23. Define the term 'sensitivity'. [Nov/Dec-2016] [Nov/Dec-2018]

Sensitivity is defined as the ratio of the magnitude of output signal to the magnitude of input signal. It denotes the smallest change in the measured variable to which instruments responds.

24. Define Repeatability. (Apr.'08)

The ability of the measuring instrument to repeat the same results during the act measurements for the same quantity is known as *Repeatability*.

25. Define Reliability. (Apr.'08)

- Reliability is defined as the probability that a given system will perform its function adequately for its specified period of lifetime under specified operating conditions.
- It is also defined as the probability of successful performance of any machine or part.

26. Define Readability. (Apr.'08)

Readability is a term frequently used for analog type instruments. It is obvious that this characteristic depends on both the instrument and observer.

Example: An instrument has a scale span of 200*mm* would have higher reliability than instrument having a scale span of 100*mm*.

27. What is the relationship between sensitivity and range? (Nov.'07)

- **Sensitivity**: The ratio of the change in output of the instrument to a change of measured variable is termed as *sensitivity*.
- **Range**: It is the minimum and maximum values of a quantity for which an instrument is designed to measure.

28. State the difference between primary and secondary transducer. (Dec.'03)

- Transducer is a device which converts the energy from one form to another. The transducer which does the first stage of energy conversion is called *primary transducer.*
- The transducer which does this form of energy into some other form is called *secondary transducer.*

29. State the dynamic characteristics of simplified measuring system. (Apr.'04)

- Speed of response
- Lag
- Fidelity
- Dynamics error

30. Define the "calibration". (Dec.'04)[Nov/Dec-2014][May/June-2014]

Calibration is defined as the process of determining and adjusting an instrument's accuracy to make sure its accuracy is within the manufacturer's specification.

31. What is Hysteresis? (Dec.'04)

Hysteresis is defined as the difference in the output for an input when this is approached from the opposite direction.

32. What is Resolution? (Nov.'08)

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

33. What is Range of measurement? (Apr.'03)

- The physical variables that are measured between two values. One is the higher calibration value H_c and the other is Lower value L_c.
- The difference between H_c and L_c is called range.

34. Differentiate between sensitivity and range with suitable example. [May/June-2014]

Example: An Instrument has a scale reading of 0.01mm to 100mm.

Here,

The sensitivity of the instrument is 0.01 mm i.e. the minimum value in the scale by which the instrument can read.

The range is 0.01 to 100 mm i.e. the minimum to maximum value by which the instrument can read.

35. Define over damped and under damped system.

- **Over damped:** Over damped is defined as the final indication of measurement is approached exponentially from one side.
- **Under damped:** The pointer approach the position corresponding to final reading and makes a number of oscillations around it.

36. Define True size.

True size is defined as the Theoretical size of a dimension.

37. Define Actual size.

Actual size is defined as the size obtained through measurement with permissible error.

38. Differentiate accuracy and Uncertainty with example.

- **Accuracy-**The maximum amount by which the result differ from true value.

  Example: Measuring accuracy is ± 0.02mm for diameter 25mm.

  Here the measurement true values lie between 24.98 to 25.02 mm.
- **Uncertainty-** The range about the measured value within the true value of the measured quantity is likely to lie at the stated level of confidence.

  Example: Measuring accuracy is about the true value = ± 0.02mm

39. What is Response time?

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

40. Define Span.

Span is defined as the algebraic difference between higher calibration values to lower calibration value.

Example: In a measurement of temperature higher value is 200^{o}C and lower value is 150^{o}Cmeans span = 200 - 150 = 50^{o}C

41. Explain the term magnification.

Magnification means the magnitude of output signal of measuring instrument time's increases to make it more readable.

42. What is the need of inspection?

The need of inspection is to determine the fitness of new made materials, products or component part and to compare the materials, products to the established standard.

43. Write short notes on Dimensional tolerance and Form Tolerance. [Nov/Dec-2013]

Dimensional Tolerance:

It is the size whose limit dimensions are specified using the upper and lower deviations. In case of a fit, the basic size of both connected elements must be the same. The tolerance of a size is defined as the difference between the upper and lower limit dimensions of the part.

Form Tolerance:

A form tolerance state that the actual surface is permitted to vary from desired geometric form. Expressions of these tolerances refer to limits of size, flatness, straightness, parallelism, perpendicularly, angularity and roundness profile of a surface and profile of a line.

44. What is meant by nominal size, tolerance and zero line? [Nov/Dec 2011][Nov/Dec-2013]

Nominal size:

The size designation used for general identification. The nominal size of the shaft and a hole are the same. The value is often expressed as a fraction.

Tolerance:

The total amount by which dimension is allowed to vary.

Zero Line:

It is a line along which represents the basic size and zero (or initial point) for measurement of upper or lower deviations.

45. Define Lag. [Nov/Dec-2011]

It is defined as a delay or time interval in an instrument between the actual event and its display.

46. Why measuring instruments should be calibrated? [Apr/May 2015][Nov/Dec-2015]

The accuracy of all measuring devices degrades 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 (Ex., oils, metal chips etc.).

47. Interpret the following geometric tolerance symbols. (Apr/May 2015)

1. Flatness

2.Cylindricity

48. What is the difference between allowance and tolerance? [Nov/Dec-2015]

- **Tolerance** is the limit of random deviation of a dimension from its nominal value.
- **Allowance** is the amount of designed deviation between two mating dimensions in a fit, which, in combination with their respective tolerances, results into a maximum and minimum clearance or interference.

49. What are the Factors affecting the inherent characteristics of measuring instrument?

(OR) [May/June-2016]

What are the factors affecting the measuring system? [Apr/May-2018]

Factors affecting the inherent characteristics of instrument:

- Repeatability & readability
- Calibration errors
- Effect of friction, backlash, etc
- Inadequate amplification for accuracy objective
- Deformation in handling or use

50. Define Parasitic and illegitimate error.[Nov/Dec-2017]

Parasitic Error:

An error often gross, which results from an incorrect execution of the measurement. Examples: Errors which result: from an incorrect reading of an indication, from the use of an instrument which has become defective, from incorrect use of an instrument.

Illegitimate error:

Mistakes and blunders such as misreading a ruler or copying down a wrong number. Systematic Error - A reproducible error that biases the data in a given direction, such as using a timer that is slow, so that all the times measured are slow by the same factor.

51. What is the difference between correction and correction factor? [Nov/Dec-2017]

Correction:

Correction is defined as a value which is added algebraically to the uncorrected result of measurement to compensate for an assumed systematic error.

Correction Factor:

If a numerical value is multiplied with uncorrected results to compensate for an assumed systematic error, it is known as correction factor.

<u>Types of Standards</u>

52. Explain line and end standards.[May/June-2016]

<u>Line Standards:</u>

When length is measured as the distance between centers of two engraved lines, it is called Line Standards. Material Standards, yard and metre are line standards E.g. Scale, Rulers, Imperial Standard Yard.

End standards:

When length is expressed as the distance between centers of two flat parallel faces, it is called End Standards. Slip Gauges, End Bars, and Ends of micrometer Anvils.

53. Distinguish between line standard and end standard. [Anna Univ.Dec.'06]

Line standard	End standard
Standards for which the length is indicated by engraved lines on a bar or scale.	Standards are in the form of blocks or bas with two faces or ends which are at a defined distance apart.
Eg. Steel Rule, Tapes.	*Eg*. Gauge blocks.

54. Define Traceability.[Apr/May-2017] [Apr/May-2019]

Traceability is the ability to verify the history, location, or application of an item by means of documented recorded identification.

55. What is the difference between gauging and measuring?
[Apr/May-2017] [Apr/May-2019]

Gauging is the measure the dimensions of (an object) with a gauge.

[Ex: When dry the assemblies can be gauged exactly]

Measurement is the quantity at which any material can be measured or can know its value.

[Ex: The size, length, or amount of something, as established by measuring]

56. Define grass error. [Nov/Dec-2020]

Grass errors, or "outliers", are errors other than random errors or systematic errors. They are often large and, by definition, unpredictable. They are typically caused by sudden changes in the prevailing physical circumstances, by system faults or by operator errors.

57. How does 'person' as a factor influence the results of a measurement? [Nov/Dec-2021]

The operator who performs tests and calibrations has a major influence on the uncertainty associated with a measurement result. Their ability to facilitate the measurement process and perform quality work has a direct impact on the measurement result.

Factors such as education, training, expertise, and technique can all influence uncertainty. Therefore, it is important conduct reproducibility experiments between operators to quantify the uncertainty (i.e. variability) in the measurement results as a result of the operator.

58. Discuss the basis of selecting a standard for a particular type of measurement?
[Nov/Dec-2021]

The standard unit for measurement to make our judgement more reliable and accurate. For proper dealing, measurement should be same for everybody. Thus there should be uniformity in measurement. For the sake of uniformity we need a common set of units of measurement, which are called standard units.

PART-B

NEED FOR MEASUREMENT:

1. What are the needs for measurements in Metrology?

Need for measurement:

- To determine the true dimensions of a part.
- To increase our knowledge and understanding of the world.
- Needed for ensuring public health and human safety.
- To convert physical parameters into meaningful numbers.
- To test if the elements that constitute the system function as per the design.
- For evaluating the performance of a system.
- For studying some basic laws of nature.
- To ensure interchangeability with a view to promoting mass production.
- To evaluate the response of the system to a particular point.
- Check the limitations of theory in actual situation.
- To establish the validity of design and for finding new data and new designs

Elements of measurements

2. State the important elements of measurements.

An important element of measurement is

- Measurand
- Reference
- Comparator

1. Measurand:

Measurand is a physical quantity or property (length, diameter, thickness, angle etc.).

2. Reference:

Reference is a physical quantity or property and comparisons are made by them.

3. Comparator:

Comparator is a device which comparing measured value with some other references.

MEASURING METHODS:

3. Explain the classification of various measuring methods.[May/June-2016] **(OR)**

Classify standard methods of measurements in detail.[Nov/Dec-2017] (OR)

Describe the types of Measurement. [Nov/Dec-2018][Apr/May-2019] [Nov/Dec-2020]

METHODS OF MEASUREMENT:

1. Direct comparison with Primary or Secondary Standard.
2. Indirect comparison with a standard through calibration system.
3. Comparative method.

4. Coincidence method.
5. Fundamental method.
6. Contact method.
7. Transposition method.
8. Complementary method.
9. Deflection method.

1) Direct method:

In this method the value of a quantity is obtained directly by comparing the unknown with the standard. It involves no mathematical calculations to arrive at the results, for example, measurement of length by a graduated scale. The method is not very accurate because it depends on human insensitiveness in making judgment.

2) Indirect method:

In this method several parameters (to which the quantity to be measured is lined with) are measured directly and then the value is determined by mathematical relationship.

For example, Measurement of density by measuring mass and geometrical dimensions.

3) Comparative method:

This method involves comparison with either a known value of the same quantity or another quantity or another quantity which is function of the quantity to be measured.

Example: Comparators.

4) Coincidence method:

In this differential method of measurement the very small difference between the given quantity and the reference is determined by the observation of the coincidence of scale marks. For example, measurements on vernier caliper.

5) Fundamental method:

Also known as the absolute method of measurement, it is based on the measurement of the base quantities used to define the quantity. For example, measuring a quantity directly in accordance with the definition of that quantity, or measuring a quantity indirectly by direct measurement of the quantities linked with the definition of the quantity to be measured.

6) Contact method and non-contact method:

In contact methods of measurements, the measuring tip of the instrument actually touches the surface to be measured. In such cases, arrangements for constant contact pressure should be provided in order to prevent errors due to excess contact pressure.

In contactless method of measurement, no contact is required. Such instrument includes tool-maker's microscope and projection comparator, etc.

Example: Vernier caliper.

7) Transposition method:

In this method, the quantity to be measured is first balanced by a known value and then it is balanced by other new known value.

Example: Determination of mass by balancing methods.

8) Complementary method:

The value of quantity to be measured is combined with known value of the same quantity.

Example: Volume determination by liquid displacement.

9) Deflection method:

The value to be measured is directly indicated by a deflection of pointer.

Example: Pressure measurement.

4. Explain the five basic elements of measuring system? (OR) [Nov/Dec-2021]
What are the various elements of metrology? With examples, explain how this elements influence the accuracy of measurements? [Nov/Dec-2015] [Nov/Dec-2016]

Elements of measuring system:

1) Measuring Instruments
2) Calibration Standards
3) Work piece
4) Person (who is carrying out the measurement)
5) Environment

The factors affecting these five elements:

1. Standard : Affected by Temperature, time, thermal expansion and elasticity.

2. Workpiece : Surface finish, cleanliness, supporting elements, and elastic Properties.

3. Instrument : Friction, error, mechanical parts.

4. Person : Ability to measure, training, cost estimation.

5. Environment : Light, Temperature, Humidity.

An example for the elements influence the accuracy of measurements

A generalized measurement system consists of the following components:

1. Primary Sensing Element
2. Variable Conversion Element
3. Variable Manipulation Element
4. Data Processing Element
5. Data Transmission System
6. Data Presentation Element

In addition to the above components, a measurement system may also have a data storage element to store measured data for future use. As the above six components are the most common ones used in many measurement systems, they are discussed in detail below

Block diagram of generalized measurement system:

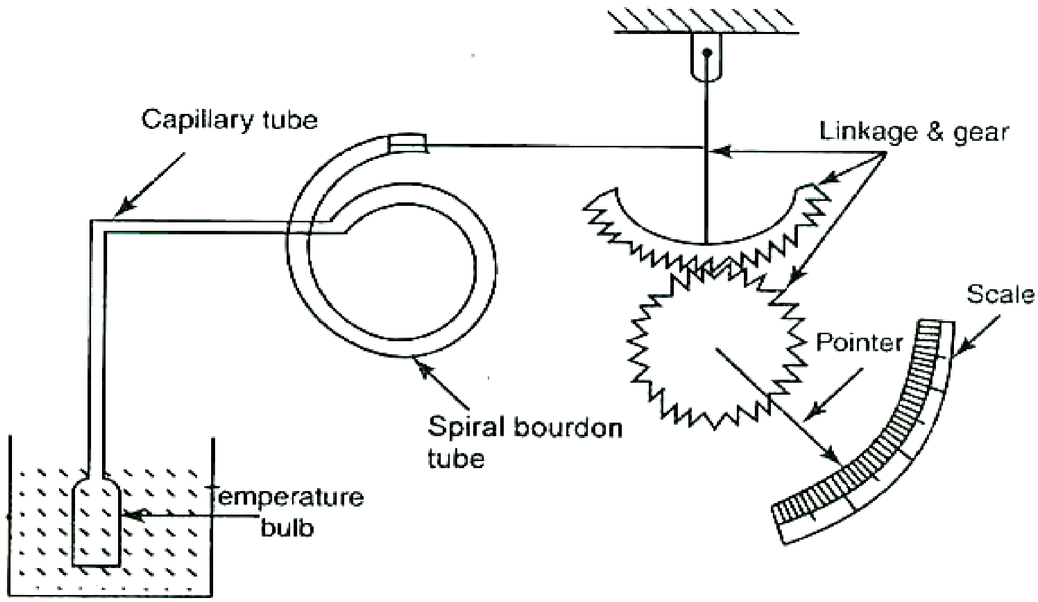
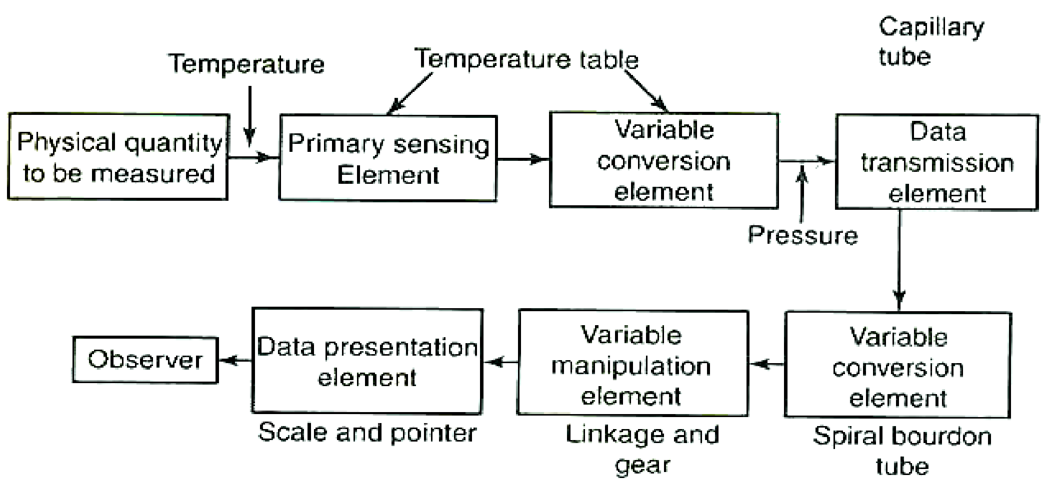


Fig. 1.4(a)



Measurement system of a filled thermal system

1. Primary Sensing Element:

The primary sensing element receives signal of the physical quantity to be measured as input. It converts the signal to a suitable form (electrical, mechanical or other form), so that it becomes easier for other elements of the measurement system, to either convert or manipulate it.

2. Variable Conversion Element:

Variable conversion element converts the output of the primary sensing element to a more suitable form. It is used only if necessary.

3. Variable Manipulation Element:

Variable manipulation element manipulates and amplifies the output of the variable conversion element. It also removes noise (if present) in the signal.

4. Data Processing Element:

Data processing element is an important element used in many measurement systems. It processes the data signal received from the variable manipulation element and produces suitable output.

Data processing element may also be used to compare the measured value with a standard value to produce required output.

5. Data Transmission System:

Data Transmission System is simply used for transmitting data from one element to another. It acts as a communication link between different elements of the measurement system. Some of the data transmission elements used to cables, wireless antennae, transducers, telemetry systems etc.

6. Data Presentation Element:

It is used to present the measured physical quantity in a human readable form to the observer. It receives processed signal from data processing element and presents the data in a human readable form. LED displays are most commonly used as data presentation elements in many measurement systems.

5. Draw the block diagram of generalized measurement system and explain the different stages with example. [Nov/Dec-2012] [Apr/May-2018]

Components of Generalized Measurement System:

A generalized measurement system consists of the following components:

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2. Variable Conversion Element
3. Variable Manipulation Element
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5. Data Transmission System
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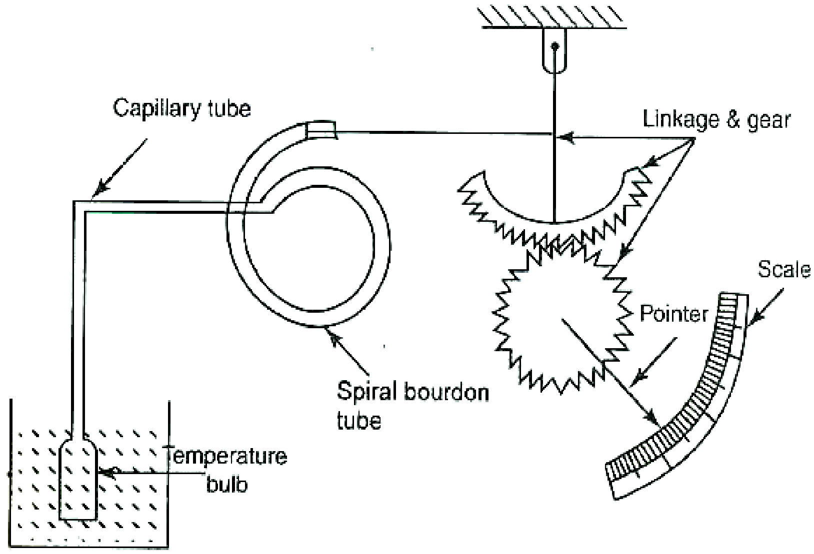
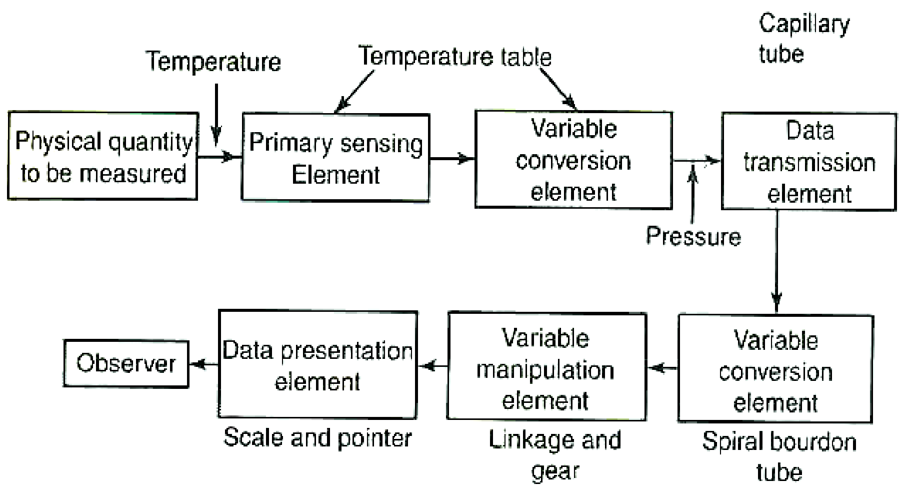


Fig. 1.4(a)



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PRECISION AND ACCURACY:

6. Write down the differences between Precision & Accuracy. [Dec.'10] [Nov/Dec-2018]

S.No	PRECISION	ACCURACY
1.	Precision is nothing but the repeatability of the process.	Accuracy is the degree of which the measured value agrees with the true valve of measured quantity.
2.	Precision is the fitness of the instrument of the dispersion of the repeated reading.	Accuracy is the desirability of observed reading from the true valve.
3.	Precision near designates accuracy	Accuracy may designate precision
4.	Precision is defined as the close relationship of the observed readings with the average valve	Accuracy is defined as the relationship between the valves of observed.
5.	Standard deviation is the index of precision for the less valve of more precision is the instrument.	The difference between the measured and true valve is the error of measurement if the error is less, then the accuracy is more.

7. Explain the factors affecting the accuracy of measuring system.

FACTORS AFFECTING THE ACCURACY OF MEASURING SYSTEM:

a) Factors affecting the standard of measurement:

- Co-efficient of thermal expansion
- Elastic properties
- Stability with time
- Geometric compatibility

b) Factors affecting the work piece to be measured:

- Co-efficient of thermal expansion
- Elastic properties
- Arrangement of supporting work piece
- Hidden geometry
- Surface defects such as scratches, waviness, etc.

c) Factors affecting the inherent characteristics of instrument:

- Repeatability & readability

TYPES OF ERRORS:

8. Discuss the different types of errors and how they can be illumined? [Nov/Dec-2021]

(OR) [Nov/Dec-2014][Apr/May-2015] [Nov/Dec-2016]

Explain the various errors in measurements. [Apr/May-2017] (OR)

What are the various possible sources of error in measurements? Explain in detail.

[Nov/Dec-2017] [Apr/May-2018] [Nov/Dec-2018] [Apr/May-2019]

TYPES OF ERRORS:

The errors can be classified into

1. Static errors
   (a) Characteristic errors
   (b) Reading errors
   (c) Environmental errors
2. Loading errors
3. Dynamic error

1. Static error:

It is from the physical nature of the various components of measuring system. The static errors due to environmental effect and other properties which influence the apparatus also reason for static errors.

a) Characteristic error:

The deviation of the output of the measuring system from the nominal performance specifications is called characteristic error.

The linearity, repeatability, hysteresis and resolution are part of the characteristic error.

b) Reading errors:

It is exclusively applied to the read out device. The reading error describes the factors parallax error and interpolation error.

The use of mirror behind the readout indicator eliminates the occurrence of parallax error. Interpolation error is a reading error resulting from the inexact evaluation of the position of index.

c) Environmental errors:

Every instrument is manufactured and calibrated at one place and it is used in some other place where the environmental conditions such as temperature, pressure, and humidity are changes.

2. Loading errors:

Loading means the measuring instrument always takes input from the signal source. Due to this, the signal source will always be altered by the act of measurement known loading.

Example:

If steam flow through the nozzle, it is very difficult to find the perfect flow rate. This is called loading error.

3. Dynamic error:

This is due to time variations in the measurand. The dynamic errors are caused by inertia, friction and clamping action.

The dynamic errors are mainly classified into

- Systematic errors or Controllable errors.
- Random errors.

9. Define–Error. Explain about the errors in measurements and its causes in detail.

(OR) **[Dec-2007][May/June-2014]**

Explain various causes of error. **[May/June-2016]**

ERRORS IN MEASUREMENT:

Error is defined as the difference between the measured value and the true value.

Error in measurement = Measured Value - True value.

The errors in measurement can be expressed either as an absolute error or on relative error.

(a) Absolute error:

The absolute error is classified into two types:

(i) True absolute error:

Algebraic difference between the results of measurement to the true value of quantity measured is called true absolute error.

(ii) Apparent absolute error:

While talking the series of measurements, algebraic difference between one of the results of measurement to the arithmetic mean is called as apparent absolute error.

(b) Relative error:

Relative error is defined as the results of the absolute error and the value of comparison used for calculation of that absolute error. The comparison may be true value or conventional true value or arithmetic mean for series of measurement.

Causes of errors:

a. Calibration error:

These are caused due to the variation in the calibrated scale from its normal value.

b. Environment errors:

These errors are caused due to humidity condition, temperature, and altitude.

c. Assembly errors:

The assembly errors are due to

1. Displaced scale i.e. incorrect fitting of the scale.
2. Non-uniform division of the scale.
3. Due to bent or distorted pointer.

d. Random errors:

There is no specific reason for causing of Random errors. It may naturally occur.

e. Systematic errors (or) Bias errors:

These types of errors caused due to repeated readings.

f. Chaotic errors:

Chaotic errors are caused due to vibrations, noises, and shocks.

10. Differentiate random errors from systematic errors.[Dec-10] [Nov/Dec-2020]

Systematic errors	Random errors
It can be controlled by magnitude and sense.	It cannot be determined form the knowledge of measuring system.
It is repetitive in nature.	It is non-consistent.
Properly analyses can be determined and reduced.	Cannot be eliminated.
These types of errors are due to improper conditions.	Random errors are in heroics in the measuring system.
These induced the variation in at exospheric, condition misalignment errors.	It induced errors due to displacement of level joints errors due to friction.

CONTROL (SENSITIVITY, RANGE, REPEATABILITY, RELIABILITY, READABILITY)

11. Write a short note on the following term. [May/June-2014][Nov/Dec-2014]

(1)Accuracy (2) Precision (3) Readability (4) Sensitivity (5) Correction and (6) Interchangeability

Accuracy:

- Accuracy may be defined as the ability of instruments to respond to a true value of a measured variable under the reference conditions.
- It refers to how closely the measured value agrees with the true value.

Precision:

- Precision is defined as the degrees of exactness for which an instrument is designed or intended to perform.
- It refers to repeatability or consistency of measurement when the instruments are carried out under identical conditions at a short interval of time.
- It is the ability of the instruments to reproduce a group of the instruments as the same measured quantity under the same conditions.

Readability:

Readability is defined as the word which is frequently used in the analog measurement. The readability is depends on the both the instruments and observer.

- Readability is defined as the closeness with which the scale of an analog instrument can be read.
- The susceptibility of a measuring instrument to having its indications converted to a meaningful number. It implies the ease with which observations can be made accurately.
- For getting better readability the instrument scale should be as high as possible.

Sensitivity:

Sensitivity of the instrument is defined as the ratio of the magnitude of the output signal to the magnitude of the input signal.

- It denotes the smallest change in the measured variable to which the instruments responds.
- Sensitivity has no unique unit. It has wide range of the units which dependent up on the instrument or measuring system.

Correction:

- Correction is defined as a value which is added algebraically to the uncorrected result of measurement to compensate for an assumed systematic error.

- If a numerical value is multiplied with uncorrected results to compensate for an assumed systematic error, it is known as correction factor.

Interchangeability:

- A part which can be substituted for the component manufactured to the small shape and dimensions is known as interchangeable part.
- The operation of substituting the part for similar manufactured components of the shape and dimensions is known as interchangeability.

12. What are the important terms in measurements?

Important terms in measurement:

a. Calibration:

If a known input is given to the measurement system the output deviates from the given input, the corrections are made in the instrument and then the output is measured. This process is called calibration.

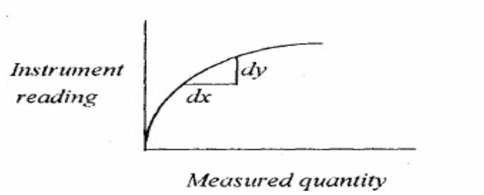
b. True size and Actual size:

True size means theoretical size of a dimension which is free from errors. Actual size mean size obtained through measurement with permissible error.

c. Sensitivity:

The instrument's sensitivity to its desired input is of concern. Its sensitivity to interfering or modifying inputs also may be of interest.

$$Sensitivity = \frac{Change\ in\ the\ ouput\ signal}{Change\ in\ the\ input\ signal}$$



d. Range:

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

e. 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 means span = 200-150 = 50°C

f. Resolution:

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

g. Threshold:

The minimum value of input signal is required to make a change or start from zero.

h. Backlash:

Lost motion or free play of mechanical element such as gears, linkage etc,

i. Magnification.

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

j. Repeatability:

Imperfections in mechanical systems can mean that during a Mechanical cycle, a process does not stop at the same location, or move through the same spot each time. The variation range is referred to as repeatability.

k. Hysteresis:

Hysteresis is defined as the difference in the output for a input when this is approached from the opposite direction.

l. Response time:

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

13. How does the reliability play the important role in quality?

Reliability:

- Reliability is defined as the probability that a given system will perform its function adequately for its specified period of lifetime under specified operating conditions.
- The probability of the successful performance of any machine or part.

The most common measures of reliability are

1. Failure rate
2. Mean time between failures (MTBF)
3. Survival percentage

1. Failure rate

The rate at which the components in a population fail is called failure rate (or) hazard rate.

Mathematical Expression for Reliability R(t):

If 'N' components are tested in a test out of which the number of components that survived during time 't' is "Ns (t)". The number of failures that occurred during the same time is "NF (t)".

2. Mean Time between Failures (MTBF):

The reciprocal of the failure rate (1/X) is called the "Mean time between failures".

There are three types of failure from this curve.

1. The quality rated failure.
2. The stress related failure.
3. The wear out failure.

The sum of these three failures gives the overall failure rate of component or system.

The failure of components in early age is called infant mortality". The middle portion of the figure represents design failure and mainly stress related and the third portion indicates old age failure i.e. product grows old and it reaches a wear-out phase which increases the failure rate.

14. Explain the following terms with suitable examples.

1) Accuracy, (2) Readability, (3) Repeatability (4) Calibration (5) Dynamic Response.

[May/June-2014][Nov/Dec-2014][Apr/May-2015]

Accuracy:

It is defined as the closeness with which the reading approaches an accepted standard valve or true valve.

Readability:

It us a tern frequently used for analog type instruments. It is obvious that this characteristic depends on both the instrument and observer.

Repeatability:

It is defined as the closeness of agreement among the no. of consecutive measurement of the output for the same valve of input under the same operating condition.

Calibration:

Calibration is the process of determining and adjusting an instrument`s accuracy to make sure its accuracy is within the manufacture`s specification.

Dynamic response:

In many practical cases, the parameters to be measured are time varying i.e., dynamic in nature. Thus, the o/p of an instrument is also time varying parameter.

The behavior of an instrument under such time varying input output condition is called dynamic response of an instrument.

Sensitivity:

$$\text{Sensitivity} = \frac{\text{Magnitude of o/p quantity (response)}}{\text{Magnitude of i/p quantity(quantity being measured)}}$$

15. Write a short on the following terms: 1) Uncertainty, (2) Reporting results [Apr.'04]

1) Uncertainty:

- The word uncertainty casts a double about the exactness of the measurement results. It is an expression of fact that for a given result of measurement there is not one valve but infinite number of valves dispersed about the result with varying degree of credibility.
- In many situations, result from different measuring instruments is used to compute the valve of a particular quantity. These measuring instrument in general will have different uncertain of measurement.
- Let the resulting quantity R be a function of `x` independent variable $x_1, x_2 \ldots x_n$)
- The variable x_1, x_2….. are quantity measured with different instruments,
- Let the uncertainty in the variable x_1, x_2…… X_n be $u_{x1}, u_{x2}, \ldots u_{xn}$. the uncertainty in the result U_r can be computed as

$$U_R = / \frac{\partial R}{\partial x_1}(Ux_1) / + / \frac{\partial R}{\partial x_2}(Ux_2) / + \cdots + / \frac{\partial R}{\partial X_n}(Ux_n) /$$

The relation between true value and estimated valve can be expressed in terms of uncertainty as.

True valve= Estimated valve± uncertainty

2) **Reporting results:**

The main of any experimental setup is to obtain results, of normally follows that some form of written record or report is to be made. The purpose of such a record will determine its form

The five type of reports:

- Executive summary
- Laboratory note or technical memo.
- Progress report
- Fell technical report
- Technical paper.

Executive summary:

The report highlights works such as what was done and what concluded. It consists of few paragraphs.

It will helpful for executive members of the origination who need brief outline of the project.

Laboratory note:

- A laboratory note is written to be read by someone thoroughly familiar with the project, such as immediate supervisor or the experimentalist himself.

- In some cases, a single page may be sufficient including a sentence or two stating the problem.

Progress report:

- A progress report is just that one of possibly several interim reports describing the current status of an ongoing project, which will even trolley, be incorporated in a full report.

Full technical report:

- It tell the complete story to one who is interested in the subject but who has been in direct touch with the specific work which per top effects of a large company or a review committee of a sponsoring Agway.
- To make the purpose of the project completely clear.

Technical paper:

It is relief summary of the project, the extent of which must be tailored to fit either a times allotment at meeting or space in a publication. The purpose is to node known the work of the writer.

16. Briefly explain the various types of input signals. [Nov/Dec-2012]

Types of Input:

The dynamic performance of both measuring and control system is determined by applying some known and predetermined input signal to its primary sensing element and then studying the behavior of the output signals.

The parameter which determines the behavior of any system is known as *input function.* The various types of input are as follows:

(1) Step input
(2) Ramp input
(3) Impulse input
(4) Sinusoidal input

These four inputs are mainly used to test the dynamic behavior of any system.

1. Step input

This type of input represents the application of sudden change in input.

The value of input is constant throughout the analysis but it is high at the starting itself.

The generalized form of input is given by

$$q_i = 0 \text{ for } t < 0$$

$$= q_{is} \text{ for } t \geq 0$$

Advantage:

It is simple to apply and easy to understand.

Disadvantage:

The system itself absorbs some energy from the input due to loading effect.

2. Ramp input

Input signal which varies linearly or at a constant rate with respect time is called as *ramp input.*

Eg: Velocity

Velocity changes directly with time. So, we can call this input as velocity input.

The generalized form of input function is given by

q_i = 0 for t < 0

=q_{is}t for t ≥ 0

Advantages:

Due to absence of sudden change in input, the dynamic behavior varies steadily according to the input signal.

Disadvantage:

Due to variation in input signal with time, both the precision of the system will be slightly affected.

3. Impulse input

Impulse input is defined as the signal which has zero value everywhere except at $t = 0$ where the magnitude is high. The nature of the input is maximum at the initial time and kept constant for a certain period of time then it is suddenly brought to zero.

An impulse functions of strength A is defined by Δ limp (t) and is illustrated in below fig .It has the following properties:

(a) The duration of the pulse is infinitesimally short (T→0)

(b) The peak of the pulse is infinitely high (A/T →α)

(c) The area of the pulse is finite and is equal to the strength A of the pulse.

If the area of the pulse is unity, it is called as unit pulse function u_1 (t).Thus p(t)= Au_1 [In Fig].The impulse function is very useful in studying the frequency response of mechanical instruments as it processes all the frequency components.

Pure impulse input function is not practically used. The combination of two input functions is used namely one step function at $t = 0$ and one inverted step function.

4. Sinusoidal input

Sinusoidal input is a unique input signal and output signal is also sinusoidal. But the output signal differs in amplitude and phase when compared to input signal.

The sinusoidal input for 8 = 0 is graphically shown in above Fig.

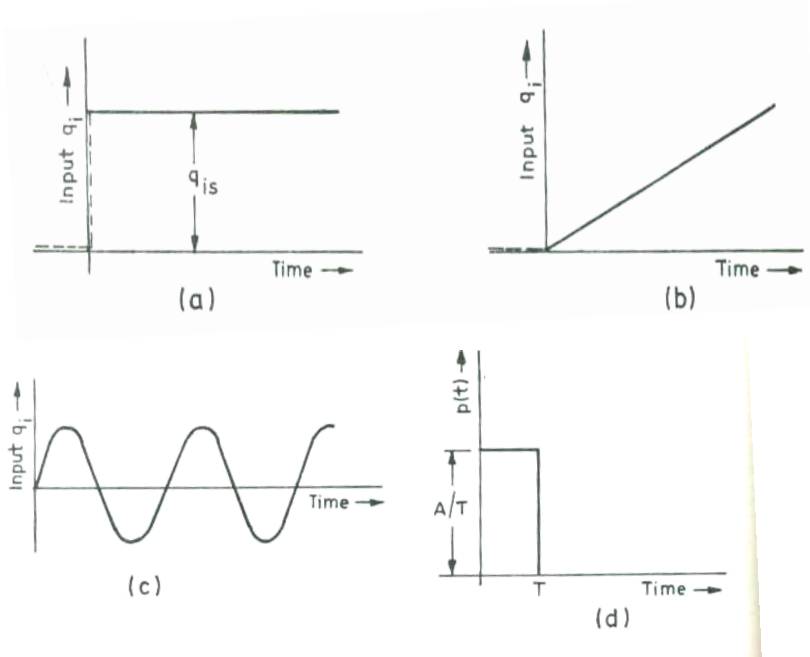


Fig. 2.6 Elementary inputs (a) Step, (b) Ramp, (c) Sinusoidal, and (d) Impulse

The three reasons of using sinusoidal input signals in dynamic behavior analysis are as follows:

(i) When the system is subjected to a periodically varying sinusoidal input signal.

(ii) When the system is subjected to a time varying signal of a complex input signal.

(iii) When the system is subjected to various types of time varying input signals like step, ramp etc, but all these 'signals can be expressed in terms of sinusoidal signals of different amplitudes and phases.

The corresponding sinusoidal input signal is

$$q_i = Ai \sin(\omega t + \delta)$$

Where Ai is amplitudes of input signal and *A* is the amplitude, *w* the frequency and 8 the phase.

This is one of the very important elementary inputs. Any input can be analyzed in terms of its sinusoidal components using Fourier analysis, and response of an instrument to sine inputs of different frequencies generates its frequency response.

17. Explain the term Repeatability and Reproducibility. [Nov/Dec-2014][Nov/Dec-2015]

(OR)

Distinguish between repeatability and reproducibility. [Apr/May-2018]

<u>Repeatability and Reproducibility:</u>

- Repeatability may be defined as the closeness of agreement among the number of consecutive measurement of the output for the same value of input under the same operating conditions.

- It may be specified in terms of units for-a given period of time. Fig. Shows the input and output relationship curve with positive and negative repeatability.
- Reproducibility may be defined as the closeness of agreement among the repeated measurements of the output for the same value of input under the same operating conditions over a period of time.
- Perfect reproducibility means that the instrument calibration does not gradually shiftover a long period of time.
- Both the reproducibility and repeatability are a measure of the closeness with which a given input may be measured again and again.
- Reproducibility may be defined by the following two terms

  (i) Stability, and

  (ii) Constancy

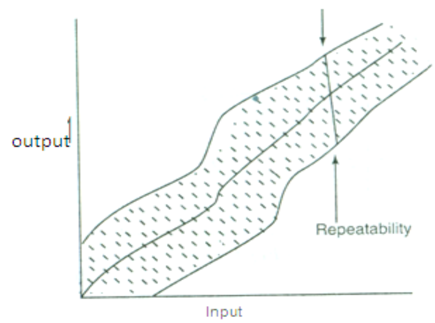


Fig: Repeatability

- Stability means the reproducibility of the mean reading of an instrument repeated on different occasions separated by intervals of time which are long enough as compared to the time of taking reading.
- Constancy means the reproducibility of the mean reading of an instrument when a constant input is presented continuously and the conditions of test are allowed to vary within the specified limits.

18. Explain the purpose of calibrating as instrument and discus the various calibrating system. [May/June-2014] (OR)

What is the need of calibration? [Apr/May-2017]

Calibration Systems Requirements

The calibration and checking of measurement tools and instruments are critically important. The reliability, accuracy, and precision of any inspection measurement relies on the correlation between the measuring devices and the master or standard.

We need exacting methods, procedures and equipment for verifying the various dimensional elements of the measuring instruments and gauges.

A calibration laboratory should be designed to furnish the following:

- Traceability of measurement
- Proper environment
- Appropriate measuring equipment
- Standard measuring procedures consistent to the state of the art.

The standards established for calibrating the measuring instruments used in controlling product quality should have the capabilities for accuracy, stability and range required for the intended use. Environmental control, giving due consideration to temperature, humidity, vibration cleanliness and other controllable factors affecting precision measurements is essential

The calibration laboratory must maintain a set of standard procedures showing the equipment required to calibrate, control requirements, a step by step procedures on how to make the actual calibration and disposition of gauges Maintenance of records of calibration of all devices is essential. Each instrument and gauge should be given a specific serial number.

TYPES OF STANDARDS:

19. Discuss the fundamentals and derived units in details. (OR)

Write detailed notes on units and standards. [May/Jun-2012]

Fundamentals SI units:

1) **For Length :**

   Metre (m) which is equal to 1650763.73 wavelengths in vacuum of the red-orange radiation corresponding to the transition between the levels 2p10 & 5d5 of the krypton-86 atom.

2) **For Mass :**

   Kilogram (kg) which is equal to the mass of International prototype of the kilogram.

3) **For Time :**

   Second (s) which is equal to the duration of 9192631770 periods of the radiation corresponding to the transition between the hyper fine levels of the ground state of the Cesium 133 atom.

4) **For Current :**

   Ampere (A) is that constant current which, if maintained in two straight parallel conductors of infinite length of negligible circular cross section & placed one metre apart in vacuum would produce between these conductors, a force equal to 2 x 10^{-7} Newton per unit length.

5) **For Temperature**: Kelvin (K) is the fraction 1/273 of thermodynamic temperature of the triple point of water.

6) **For Luminous intensity:** Candela (Cd) is the luminous intensity in the perpendicular direction of a surface of 1/600,000 m^2 of a black body at the temperature of freezing platinum under a pressure of 101325 N/m^2.

7) **For amount of substance:** Mole (mol) is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of Carbon-12.

Supplementary SI units:

1. **For Plane angle** **:** Radian (rad)
2. **For Solid angle** **:** Steradian (sr)

Derived SI units:

1) **For Frequency** **:** Hertz (1 Hz = 1 cycle per second)
2) **For Force** **:**Newton (1 N = 1 kg-m/s^2)
3) **For Energy** **:**Joule (1 J = 1 N-m)
4) **For Power** **:**Watt (1 W = 1 J/s)

20. Define standard and explain the different types of standards of measurements.

[Apr/May-2017] [Nov/Dec-2018]

Standard:

It is the physical embodiment of a unit. For every kind of quantity to be measured, there should be a unit to express the result of the measurement & a standard to enable the measurement.

Classification of Standards:

1. Line standards :

When length is measured as the distance between centers of two engraved lines, it is called Line Standards. Material Standards, yard and metre are line standards E.g. Scale, Rulers, Imperial Standard Yard.

Characteristics of Line Standards:

i. Scale can be accurately embalmed, but the engraved lines posses thickness and it is not possible to accurately measure.
ii. Scale is used over a wide range.
iii. Scale markings are subjected to wear. However the ends are subjected to wear and this leads to undersize measurements.
iv. Scale does not possess built in datum. Therefore it is not possible to align the scale with the axis of measurement.
v. Scales are subjected to parallax errors.
vi. Assistance of magnifying glass or microscope is required.

2. End standards :

When length is expressed as the distance between centers of two flat parallel faces, it is called End Standards. Slip Gauges, End Bars, and Ends of micrometer Anvils.

Characteristics of End Standards:

(i) Highly accurate and used for measurement of closed tolerances in precision engineering as well as standard laboratories, tool rooms, inspection departments.

(ii) They require more time for measurement and measure only one dimension.

(iii) They wear at their measuring faces

(iv) They are not subjected to parallax error.

21. Differentiate between Line Standard and End Standards.

Sl.No	Characteristics	Line Standard	End Standard
1.	Principle	Length is expressed as distance between 2 lines	Length is expressed as distance between 2 ends
2.	Accuracy	Ltd. To ± 0.2mm.	Highly accurate of closed tolerances to ±0.001mm
3.	Ease	Quick and easy	Time consuming and requires skill
4.	Effect of wear	Wear at only the ends	wear at measuring surfaces
5.	Alignment	Cannot be easily aligned	Easily aligned
6.	Parallax Effect	Subjected to parallax effect	not subjected to parallax effect

22. Discuss about the primary and secondary calibration of the measuring instruments. [Apr/May-2018]

<u>Primary, secondary, tertiary & working standards:</u>

Primary standard:

It is only one material standard and is preserved under the most careful conditions and is used only for comparison with Secondary standard.

Secondary standard:

It is similar to Primary standard as nearly as possible and is distributed to a number of places for safe custody and is used for occasional comparison with Tertiary standards.

Tertiary standard:

It is used for reference purposes in laboratories and workshops and is used for comparison with working standard.

Working standard:

It is used daily in laboratories and workshops. Low grades of materials may be used.

23. An electronic caliper was used to measure the length of an object. Five measurements were made. The results of the five measurements are: 21.53 mm, 21.51 mm, 20.52 mm, 21.48 mm and 21.42 mm. The workshop temperature during measurement was 21°C. The calibration certificate of the electronic caliper says that the device will read within ± 0.02mm of the correct answer if it is used correctly and when the temperature is within 0 to 40°C. Estimate the expanded uncertainty at a coverage factor of 2 providing coverage probability of approximately 95%. [Nov/Dec-2020]

The result of the calibration is the maximum range of error, as indicated from measurements over a series of ten individual gauge blocks along the micrometer screw.

Accuracy of micrometer traverse calibrated against steel Grade 1 Gauge Blocks

Source of uncertainty	Value	Probability distribution	Divisor	Standard uncertainty /µm
Uncorrected errors in length of gauge block (a) at point of minimum error	0.25 µm	Rectangular	√3	0.144
Uncorrected errors in length of gauge block (b) at point of maximum error	0.3 µm	Rectangular	√3	0.173
Uncertainty in calibration of gauge block (a)	0.1 µm	Normal	2	0.050
Uncertainty in calibration of gauge block (b)	0.1 µm	Normal	2	0.050
Repeatability at point (a) +	0.5 µm	Normal	1	0.500
Repeatability at point (b) +	0.5 µm	Normal	1	0.500
Resolution of micrometer (2.0 µm)	1.0 µm	Rectangular	√3	0.577
Effect of temperature differences between micrometer and gauge blocks *	0.14 µm	Rectangular	√3	0.081
Combined standard uncertainty	-	Normal	-	0.943
Expanded uncertainty	-	Normal (k = 2)	-	1.885

+Repeatability determined as the standard deviation of ten repeated readings for a typical, previously calibrated instrument.

* Basing temperature effects on an expansion coefficient of 11 × 10-6 /°C, with temperature difference of 0.5 °C over 25 mm.

Calculate the combined standard uncertainty as follows,

$$u_c = \sqrt{0.144^2 + 0.173^2 + 0.050^2 + 0.050^2 + 0.500^2 + 0.500^2 + 0.577^2 + 0.081^2} \ .$$

The uncertainty of the above measured values has been calculated in accordance with the ISO document 'Guide to the expression of uncertainty in measurement'. The expanded uncertainty has been calculated to be ± 0.002 mm and is based on a standard uncertainty multiplied by a coverage factor k = 2 providing a confidence probability of approximately 95%.

REVIEW QUESTIONS

PART-A

1. Define- metrology? [Nov/Dec-06]

2. Define: Measurand.[Nov/Dec-09]

3. What is legal metrology? [May/June-2014]

4. What are the applications of Legal metrology?

5. Give any four methods of measurement.

6. Give classification of measuring instruments.

7. Define: Deterministic Metrology.

8. What is the basic Principle of measurement?

9. What is the need for metrology?

10. What are the important elements of measurements? [Nov/Dec-2018]

11. What are the elements of generalized measurement system?

12. Differentiate between precision and accuracy. [Nov/Dec-2014] [Nov/Dec-2016]

13. Define error.

14. What is mean by error in measurement?

15. Classify the errors.

16. Define static and dynamic characteristics (static and dynamic response) of a measuring instrument. [Nov/Dec-2013]

17. Define systematic errors. [Dec-05]

18. Define system error and correction?(Dec.’09)

19. Classify the Absolute error.

20. Distinguish between relative error and random error. (Nov.’07)

21. What are the various sources of error? (Dec.’08)

22. Mention the various methods used for limiting temperature errors.[Nov.’04]

23. Define the term ‘sensitivity’. [Nov/Dec-2016] [Nov/Dec-2018]

24. Define Repeatability. (Apr.’08)

25. Define Reliability. (Apr.’08)

26. Define Readability. (Apr.’08)

27. What is the relationship between sensitivity and range? (Nov.’07)

28. State the difference between primary and secondary transducer. (Dec.’03)

29. State the dynamic characteristics of simplified measuring system. (Apr.’04)

30. Define the “calibration”. (Dec.’04)[Nov/Dec-2014][May/June-2014]

31. What is Hysteresis? (Dec.’04)

32. What is Resolution? (Nov.'08)
33. What is Range of measurement? (Apr.'03)
34. Differentiate between sensitivity and range with suitable example.[May/June-2014]
35. Define over damped and under damped system.
36. Define True size.
37. Define Actual size.
38. Differentiate accuracy and Uncertainty with example.
39. What is Response time?
40. Define Span.
41. Explain the term magnification.
42. What is the need of inspection?
43. Write short notes on Dimensional tolerance and Form Tolerance.[Nov/Dec-2013]
44. What is meant by nominal size , tolerance and zero line? [Nov/Dec 2011][Nov/Dec-2013]
45. Define Lag. [Nov/Dec-2011]
46. Why measuring instruments should be calibrated? [Apr/May 2015][Nov/Dec-2015]
47. Interpret the following geometric tolerance symbols. [Apr/May 2015]
48. What is the difference between allowance and tolerance? [Nov/Dec-2015]
49. What are the Factors affecting the inherent characteristics of measuring instrument?
50. Define Parasitic and illegitimate error.[Nov/Dec-2017]
51. What is the difference between correction and correction factor? [Nov/Dec-2017]
52. Explain line and end standards.[May/June-2016]
53. Distinguish between line standard and end standard. [Anna Univ.Dec.'06]
54. Define Traceability.[Apr/May-2017] [Apr/May-2019]
55. What is the difference between gauging and measuring? [Apr/May-2017] [Apr/May-2019]
56. Define grass error. [Nov/Dec-2020]
57. How does 'person' as a factor influence the results of a measurement? [Nov/Dec-2021]
58. Discuss the basis of selecting a standard for a particular type of measurement? [Nov/Dec-2021]

PART-B

1. What are the needs for measurements in Metrology?
2. State the important elements of measurements.
3. Explain the classification of various measuring methods.[May/June-2016] (OR)
   Classify standard methods of measurements in detail.[Nov/Dec-2017]
   Describe the types of Measurement. [Nov/Dec-2018]

4. Explain the five basic elements of measuring system? (OR)

What are the various elements of metrology? With examples, explain how this elements influence the accuracy of measurements?[Nov/Dec-2015] [Nov/Dec-2016]

5. Draw the block diagram of generalized measurement system and explain the different stages with example.[Nov/Dec-2012] [Apr/May-2018]

6. Write down the differences between Precision & Accuracy.[Nov/Dec-2018]

7. Explain the factors affecting the accuracy of measuring system.

8. Discuss the different types of errors and how they can be illumined?

(OR) [Nov/Dec-2014][Apr/May-2015] [Nov/Dec-2016]

Explain the various errors in measurements. [Apr/May-2017] (OR)

What are the various possible sources of error in measurements? Explain in detail.

[Nov/Dec-2017] [Apr/May-2018] [Nov/Dec-2018]

9. Define–Error. Explain about the errors in measurements and its causes in detail.

(OR) [Dec-2007][May/June-2014]

Explain various causes of error.[May/June-2016]

10. Differentiate random errors from systematic errors.[Dec-10]

11. Write a short note on the following term.[May/June-2014][Nov/Dec-2014]

(1)Accuracy (2) Precision (3) Readability (4) Sensitivity (5) Correction and (6) Interchangeability

12. What are the important terms in measurements?

13. How does the reliability play the important role in quality?

14. Explain the following terms with suitable examples.

1) Accuracy, (2) Readability, (3) Repeatability (4) Calibration (5) Dynamic Response.

[May/June-2014][Nov/Dec-2014][Apr/May-2015]

15. Write a short on the following terms:1) Uncertainty, (2) Reporting results. [Apr.’04]

16. Briefly explain the various types of input signals. [Nov/Dec-2012]

17. Explain the term Repeatability and Reproducibility.[Nov/Dec-2014][Nov/Dec-2015]

(OR)

Distinguish between repeatability and reproducibility. [Apr/May-2018]

18. Explain the purpose of calibrating as instrument and discus the various calibrating system.

(OR)

What is the need of calibration? [Apr/May-2017]

19. Discuss the fundamentals and derived units in details. (OR)

Write detailed notes on units and standards. [May/Jun-2012]

20. Define standard and explain the different types of standards of measurements.

[Apr/May-2017] [Nov/Dec-2018]

21. Differentiate between Line Standard and End Standards.

22. Discuss about the primary and secondary calibration of the measuring instruments.

[Apr/May-2018]

23. An electronic caliper was used to measure the length of an object. Five measurements were made. The results of the five measurements are: 21.53 mm, 21.51 mm, 20.52 mm, 21.48 mm and 21.42 mm. The workshop temperature during measurement was 21°C. The calibration certificate of the electronic caliper says that the device will read within ± 0.02mm of the correct answer if it is used correctly and when the temperature is within 0 to 40°C. Estimate the expanded uncertainty at a coverage factor of 2 providing coverage probability of approximately 95%. [Nov/Dec-2020]