IAE I Question Bank with Answers

Q.No		Question	M	CO
1.		List the various errors in measurement.	2	CO-1
2.		Define Calibration	2	CO-1
3.		What is readability?	2	CO-1
4.		Mention any four methods of measurement?	2	CO-1
5.		Why are sine bars not used for measuring large angles?	2	CO-2
6.		Classify the measuring instruments.	2	CO-1
7.		Define Calibration.	2	CO-1
8.		What is Range of measurement?	2	CO-1
9.		Mention any four methods of measurement.	2	CO-1
10.		List any two linear measuring instruments.	2	CO-2
		PART B		
6.	(a)	Write detailed notes on: i) Repeatability and Reproducibility ii) Systematic and Random errors	13	CO-1
	(b)	Define standards. Discuss different type of standards in detail.	13	CO-1
7.	(a)	Illustrate the working principle of Pneumatic comparator with neat sketch.	13	CO-2
	(b)	Explain the precautionary measures one shall follow at various stages of using slip gauges.	13	CO-2
		PART C – (1 x 14 = 14 Marks)		
8.	(a)	With suitable example explain the elements of generalized measurement system.	14	CO-1
	(b)	Distinguish between precision and accuracy with suitable illustrations.	14	CO-1
		PART B		
6.	(a)	Define standards. Discuss different type of standards in detail.	13	CO-1
	(b)	Draw the block diagram of generalized measurement system and explain different stages with examples.	13	CO-1
7.	(a)	Explain the construction and working of Vernier Caliper.	13	CO-2
	(b)	Illustrate the working principle of mechanical comparator with neat sketch.	13	CO-2
		PART C		
8.	(a)	Describe the different types of error in measurement and their causes and control methods in detail?	14	CO-1
	(b)	Distinguish between precision and accuracy with suitable illustrations.	14	CO-1

UNIT I- Concept of Measurements

2 MARKS

1. What is Range of measurement?

The physical variable that is measured between two values is called as a range. 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 0.0lmm 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: 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 is called as deterministic metrology. The new techniques such as 3D error compensation by CNC systems are applied.

7. Define over damped and under damped system.

Over damped - The final indication of measurement is approached exponentially from one side.

Under damped - The pointer approaching the position corresponding to final reading and makes a number of oscillations around it.

8. Give any four methods of measurement

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

9. 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 upon 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 ± 0.02mm for diameter 25mm. Here the measurement true values lie between 24.98 to25.02 mm. Uncertainty about the true value = ± 0.02mm

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 1500C means span = 200 - 150 = 50'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. Define Repeatability:

The ability of the measuring instrument to repeat the same results g the act measurements for the same quantity is known as repeatability.

19. Explain the term magnification:

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

20. Classify the Absolute error.

The absolute error is classified into

1. True absolute error
2. Apparent absolute error

21. What is 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.

22. Classify the errors

The errors can be classified into

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

23. 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.

24. What are the applications of Legal metrology?

1. Industrial Measurement.
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 materials, products to the established standard, inspections are needed.

25. What are the important elements of measurements?

The important elements of a measurement

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 "Notional service of Legal Metrology". The main objective is to, maintain uniformity of measurement in a particular country.

UNIT II – Linear and Angular Measurements

2 MARKS

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) Thick fiess

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) Autocollimator

(v) Angle dekkor

32. What are 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 usedfor 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 is affected 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 is known as least count. Least count of a mechanical comparator is 0.0 1 mm

37. How the mechanical comparator is used? State with an 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 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.

(ii) There is no external supply such as electricity, air required

(iii) It has very simple mechanism and is cheaper when compared to other types.

(iv)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 arrangement. 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 on 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. wheat stone 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 modulation or radio oscillation is followed.

44. Mention the importantparts 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 ranges.

(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 meter 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 a 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 all during the measurement.

(iv)High magnification is possible.

(v) There is no interference of measuring head and indicating device because the measuring head is kept away from the indicating device.

(vi) lt is a suitable method to check ovalty and taperness of circular bore.

UNIT -1 BASICS OF METROLOGY

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)

Gaugingis 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

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

Standards

The term standard is used to denote universally accepted specifications for devices. Components are processes which ensure conformity and interchangeability throughout a particular industry. A standard provides a reference for assigning a numerical value to a measured quantity. Each basic measurable quantity has associated with it an ultimate standard. Working standards, those used in conjunction with the various measurement making instruments.

The national institute of standards and technology (NIST) formerly called National Bureau of Standards (NBS), it was established by an act of congress in 1901, and the need for such body had been noted by the founders of the constitution. In order to maintain accuracy, standards in a vast industrial complex must be trace able to a single source, which may be national standards.

The following is the generalization of echelons of standards in the national measurement system.

1. Calibration standards
2. Metrology standards
3. National standards

Calibration standards: Working standards of industrial or government alllaboratories.

Metrology standards: Reference standards of industrial or Government alllaboratories.

National standards: It includes proto type and natural phenomenon of SI(Systems International), the world wide system of weight and measures standards. Application of precise measurement has increased so much, that a single national laboratory to perform directly all the calibrations and standardization required by large country with high technical development. It has led to the establishment of a considerable number of standardizing

laboratories in industry and in various other areas. A standard provides a reference or datum for assigning a numerical value to a measured quantity.

Classification of Standards

To maintain accuracy and interchangeability it is necessary that Standards to be trace able to a single source, usually the National Standards of the country, which are further linked to International Standards. The accuracy of National Standards is transferred to working standards through a chain of intermediate standards in a manner given below.

- National Standards
- National Reference Standards
- Working Standards
- Plant Laboratory Reference Standards
- Plant Laboratory Working Standards
- Shop Floor Standards

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)

ERRORS IN MEASUREMENTS

It is never possible to measure the true value of a dimension there is always some error. The error in measurement is the difference between the measured value and the true value of the measured dimension.

Error in measurement = Measured value-True value

Absolute Error

True absolute error:

It is the algebraic difference between the result of measurement and the conventional true value of the quantity measured.

Apparent absolute error:

If the series of measurement are made and then the algebraic difference between one of the results of measurement and the arithmetical mean is known as apparent absolute error.

Relative Error:

It is the quotient of the absolute error and the value of comparison use or calculation of that absolute error. This value of comparison may be the true value, the conventional true value or the arithmetic mean for series of measurement.

Types of Errors

Systematic Error

These errors include calibration errors, error due to variation in the atmospheric condition variation in contact pressure etc. If properly analyzed, these errors can be determined and reduced or even eliminated hence it also called controllable errors. All other systematic errors can be controlled in a magnitude and sense except personal error.

These errors results from irregular procedure that is consistent in action. These errors are repetitive in nature and are of constant and similar form.

Random Error

These errors are caused due to variation in position of setting standard and work –piece errors. Due to displacement of level joints of instruments, due to back lash and friction, these error are induced. Specific cause, magnitude and sense of these errors cannot be determined from the knowledge of measuring system or condition of measurement. These errors are non-consistent and hence the name random errors.

Environmental Error

These errors are caused due to effect of surrounding temperature, pressure and humidity on the measuring instrument. External factors like nuclear radiation, vibrations and magnetic field also leads to error. Temperature plays an important role where high precision is required .e.g. while using slip gauges, due to handling the slip gauges may acquire human body temperature, where as the work is at 20°C. A 300mm length will go in error by 5microns which is quite a considerable error. To avoid errors of this kind, all metrology laboratories and standard rooms worldwide are maintained at 20°C.

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

Precision

The terms precision and accuracy are used in connection with the performance of the instrument. Precision is the repeatability of the measuring process. It refers to the group of measurements for the same characteristics take number identical conditions. It indicates to what extent the identically performed measurements agree with each other. If the instrument is not precise it will give different (widely varying) results for the same dimension when measured again and again. These to observations will scatter about the mean. The scatter of these measurements is designated as σ, the standard deviation. It is used as an index of precision. The less the scattering more precise is the instrument. Thus, lower, the value of σ, the more precise is the instrument.

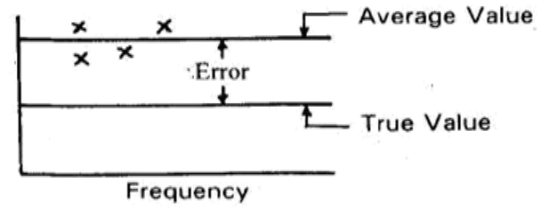
Accuracy

Accuracy is the degree to which the measured value of the quality characteristic agrees with the true value. The difference between the true value and the measured value is known as error of measurement. It is practically difficult to measure exactly the true value and therefore a set of observations is made whose mean value is taken as the true value of the quality measured.

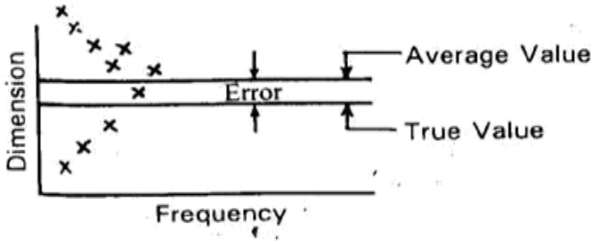
Distinction between Precision and Accuracy

Accuracy is very often confused with precision though much different. The distinction between the precision and accuracy will become clear by the following example. Several measurements are made on a component by different types of instruments (A, B and C respectively) and the results are plotted. In any set of measurements, the individual measurements are scattered about the mean, and the precision signifies how well the various measurements performed by same instrument on the same quality characteristic agree with each other. The difference between the mean of set of readings on the same quality characteristic and the true value is called as error. Less the error more accurate is the instrument. Figure shows that the instrument A is precise since the results of number of measurements are close to the average value. However, there is a large difference (error) between the true value and the average value hence it is

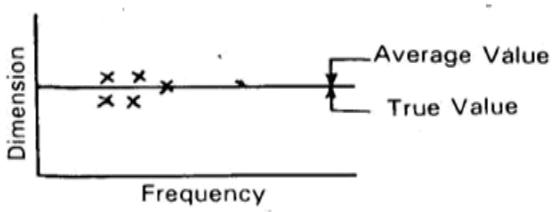
not accurate. The readings taken by the instruments are scattered much from the average value and hence it is not precise but accurate as there is a small difference between the average value and true value.



(a) Precise but not accurate



(b) Accurate but not precise



(c) Accurate & precise

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

METHODS OFMEASUREMENTS

These are the methods of comparison used in measurement process. In precision measurement various methods of measurement are adopted depending upon the accuracy required and the amount of permissible error.

The methods of measurement can be classified as:

1. Direct method
2. Indirect method
3. Absolute or Fundamental method
4. Comparative method
5. Transposition method

6. Coincidence method
7. Deflection method
8. Complementary method
9. Contact method
10. Contactless method

Direct method of measurement:

This is a simple method of measurement, in which the value of the quantity to be measured is obtained directly without any calculations. For example, measurements by using scales, vernier calipers, micrometers, bevel protector etc. This method is most widely used in production. This method is not very accurate because it depends on human in sensitiveness in making judgment.

Indirect method of measurement:

In indirect method the value of quantity to be measured is obtained by measuring other quantities which are functionally related to the required value. E.g. Angle measurement by sine bar, measurement of screw pitch diameter by three wire method etc.

Absolute or Fundamental method:

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.

Comparative method:

In this method the value of the quantity to be measured is compared with known value of the same quantity or other quantity practically related to it. So, in this method only the deviations from a master gauge are determined, e.g., dial indicators, or other comparators.

Transposition method:

It is a method of measurement by direct comparison in which the value of the quantity measured is first balanced by an initial known value A of the same

quantity, and then the value of the quantity measured is put in place of this known value and is balanced again by another known value B. If the position of the element indicating equilibrium is the same in both cases, the value of the quantity to be measured is AB. For example, determination of a mass by means of a balance and known weights, using the Gauss double weighing.

Coincidence method:

It is a differential method of measurement in which a very small difference between the value of the quantity to be measured and the reference is determined by the observation of the coincidence of certain lines or signals. For example, measurement by vernier caliper micrometer.

Deflection method:

In this method the value of the quantity to be measured is directly indicated by a deflection of a pointer on a calibrated scale.

Complementary method:

In this method the value of the quantity to be measured is combined with a known value of the same quantity. The combination is so adjusted that the sum of these two values is equal to predetermined comparison value. For example, determination of the volume of a solid by liquid displacement.

Method of measurement by substitution:

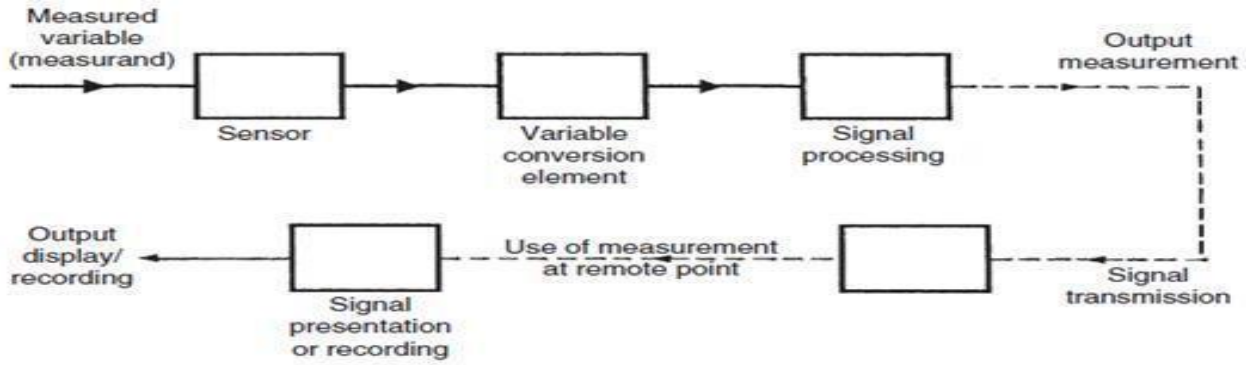
It is a method of direct comparison in which the value of a quantity to be measured is replaced by a known value of the same quantity, so selected that the effects produced in the indicating device by these two values are the same.

Method of null measurement:

It is a method of differential measurement. In this method the difference between the value of the quantity to be measured and the known value of the same quantity with which it is compared is brought to zero.

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

A measuring system exists to provide information about the physical value of some variable being measured. In simple cases, the system can consist of only a single unit that gives an output reading or signal according to the magnitude of the unknown variable applied to it. However, in more complex measurement situations, a measuring system consists of several separate elements as shown in Figure



The various elements of measurement system are,

a. Primary sensing Element

b. Variable conversion element.

c. Variable manipulation element

d. Data transmission element.

e. Data processing Element

f. Data presentation element.

a. Primary sensing Element

it is the first element which receives energy from the measured medium and it produces an output corresponding to the measurand. This output is then converted into an analogous electrical signal by a transducer.

b. Variable conversion element.

It converts the output electrical signal of the primary sensing element into a more suitable form signal without changing the information containing in the input signal. In some instruments, there is no need of using a variable conversion element while some other instruments require the variable conversion element.

c. Variable manipulation element

This element is used to manipulate the signal presented to it and preserving the original nature of the signal. In other words, it amplifies the input signal to the required magnification. For example an electronic voltage amplifierreceives a small voltage as input and it produces greater magnitude of voltage as output. A variable manipulation element does not necessarily follow a variable conversion element and it may precede it.

d. Data transmission element.

It transmits the data from one element to the other. It may be as shaft and gear assembly system or as complicated as a telemetry system which is used to transmit the signal from one place to another.

e. Data processing Element

It is an element which is used to modify the data before displayed or finally recorded. It may be used for the following purposes.

To convert the data into useful form

To separate the signal hidden in noise

It may provide corrections to the measured physical variables to compensate for zero offset, temperature error, scaling etc

f. Data presentation element.

These are the elements that they finally communicate the information of measured variables to a human observer for monitoring, controlling or analyzing purposes. The value of measured variables may be indicated by an analog indicator, digital indicator, or by a recorder

Part C

1. 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)

1. Repeatability

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.

2) Reproducibility

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 shift over a long period of time.

3) **Systematic error:**

It is the error which during several measurements, made under the same conditions, of the same value of a certain quantity, remains constant in absolute value and sign or varies in a predictable way in accordance with a specified law when the conditions change. The causes of these errors may be known or unknown. The errors may be constant or variable. Systematic errors are regularly repetitive in nature.

4) **Random error:**

This error varies in an unpredictable manner in absolute value & in sign when a large number of measurements of the same value of a quantity are made under practically

5. Static response:

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

6. 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.

2. With suitable example explain the elements of generalized measurement system

Components of Generalized Measurement System:

A generalized measurement system consists of the following components:

Primary Sensing Element

Variable Conversion Element

Variable Manipulation Element

Data Processing Element

Data Transmission System

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:

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 are 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.

UNIT-2 LINEARAND ANGULAR MEASUREMENTS

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 any deviation in the height of the component, it will be indicated by the pointer.

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

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

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

- Accuracy of the comparator mainly depends on the accuracy of the rack and pinion arrangement. Any slackness will reduce accuracy.
- 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 use various 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 because the 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)

- The gauge block surface should be cleaned from dust particles.
- Wringing and slipping process should be done before measurement.

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

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

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

- The rollers must have equal diameter and equal cylinders
- The rollers should be placed parallel to each other and also to the upper face.
- 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 bore diameter.

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

11. Give a brief note on slip gauges and what are the safety precaution to be followed in the use of slip gauge blocks and also explain the type of limit gauge with neat sketches (APRIL /MAY 2015) ?(NOV/DEC 2016)

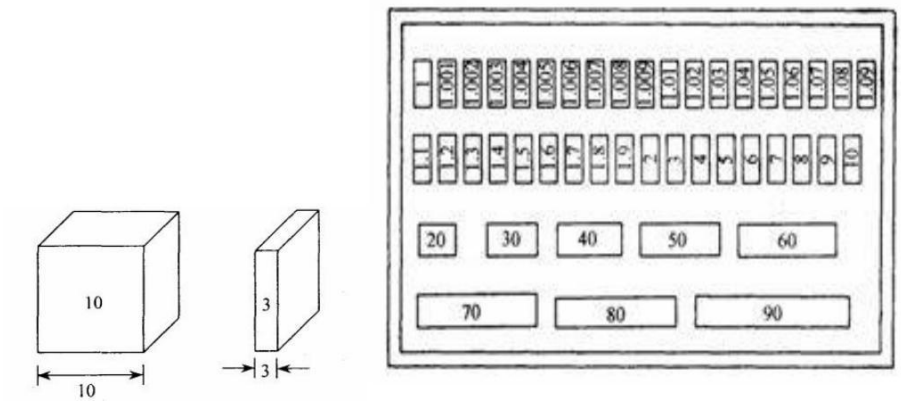
SLIPGAUGES

These may be used as reference standards for transferring the dimension of the unit of length from the primary standard to gauge blocks of lower accuracy and for the verification and graduation of measuring apparatus.

These are high carbon steel hardened, ground and lapped rectangular blocks, having cross sectional area 0f 30mm, 10mm. Their opposite faces are flat, parallel and are accurately the stated distance apart.

The opposite faces are of such a high degree of surface finish, that when the blocks are pressed together with a slight twist by hand, they will wring together. They will remain firmly attached to each other. They are supplied in sets of 112 pieces down to 32pieces.

Due to properties of slip gauges, they are built up by, wringing into combination which gives size, varying by steps of 0.01 mm and the overall accuracy is of the order of 0.00025mm. Slip gauges with three basic forms are commonly found, these are rectangular, square with center hole, and square without center hole.



Precautions

- The blocks should be kept in the box and it it should not dropped on the irregular surfaces.
- Surfaces of slip gauges should be cleaned before it is used.
- The slip gauge block should be in particular temperature condition to eliminate the thermal expansion which causes in accuracy during measurement.
- While using slip gauses for measurement it should be kept iin a flat surface to get high accurate readings.

LIMITGAUGES

- A limit gauge is not a measuring gauge. Just they are used as inspecting gauges.
- The limit gauges are used in inspection by methods of attributes.
- This gives the information about the products which maybe either within the prescribed limit or not.
- By using limit gauges report, the control charts of P and C charts are drawn to control invariance of the products.
- This procedure is mostly performed by the quality control department of each and every industry.
- Limit gauge are mainly used for checking for cylindrical holes of identical components with a large numbers in mass production.

Purpose of using limit gauges

- Components are manufactured as per the specified tolerance limits, upper limit and lower limit. The dimension of each component should be within this upper and lower limit.
- If the dimensions are outside these limits, the components will be rejected.
- It is just enough whether the size of the component is within the prescribed limits or not. For this purpose, we can make use of gauges known as limit gauges.

The common types are as follows:

1) Plug gauges.

2) Ring gauges.

3) Snap gauges.

PLUGGAUGES

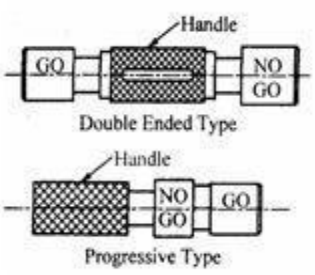
- The ends are hardened and accurately finished by grinding. One end is the GO end and the other end is NOGO end.
- Usually, the GO end will be equal to the lower limit size of the hole and the NOGO end will be equal to the upper limit size of the hole.
- If the size of the hole is within the limits, the GO end should go inside the hole and NOGO end should not go.
- If the GO end and does not go, the hole is under size and also if NOGO end goes, the hole is over size. Hence, the components are rejected in both the cases

1. **Double ended plug gauges**

In this type, the GO end and NOGO end are arranged on both the ends of the plug. This type has the advantage of easy handling.

2. **Progressive type of plug gauges**

In this type both the GO end and NOGO end are arranged in the same side of the plug. We can use the plug gauge ends progressively one after the other while checking the hole. It saves time. Generally, the GO end is made larger than the NOGO end in plug gauges.

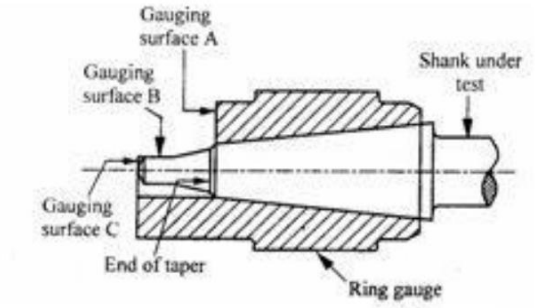


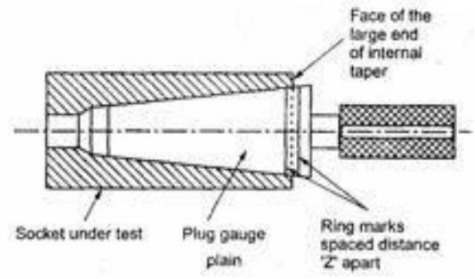
TAPER PLUG GAUGE

Taper plug gauges are used to check tapered holes. It has two check lines. One is a GO line and another is a NOGO line. During the checking of work, NOGO line remains outside the hole and GO line remains inside the hole.

They are various types taper plug gauges are available as shown in fig. Such as

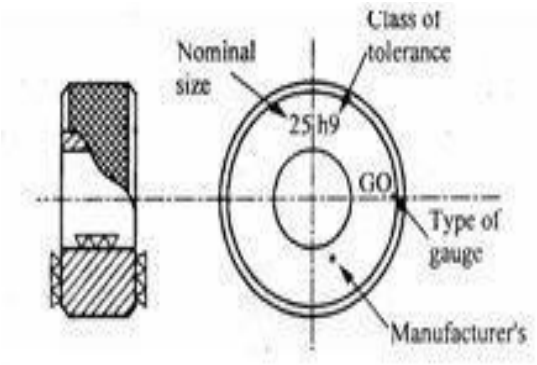
1) Taper plug gauge— plain
2) Taper plug gauge— tanged.
3) Taper ring gauge plain
4) Taper ring gauge — tanged





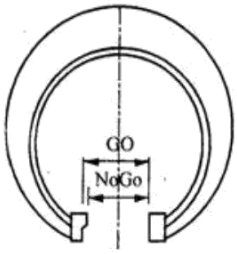
RING GAUGES

- Ring gauges are mainly used for checking the diameter of shafts having a central hole. The hole is accurately finished by grinding and lapping after taking hardening process.
- The periphery of the ring is knurled to give more grips while handling the gauges. We have to make two ring gauges separately to check the shaft such as GO ring gauge and NOGO ring gauge.
- But the hole of GO ring gauge is made to the upper limit size of the shaft and NOGO for the lower limit.
- While checking the shaft, the GO ring gauge will pass through the shaft and NO GO will not pass.
- To identify the NOGO ring gauges easily, are mark or a small groove cut on its periphery.



SNAP GAUGE

Snap gauges are used for checking external dimensions. They are also called a snap gauges. The different types of snap gauges are:



Double Ended Snap Gauge

This gauge is having two ends in the form of anvils. Here also, the GO anvil is made to lower limit and NOGO anvil is made to upper limit of the shaft. It is also known as solid snap gauges

Progressive Snap Gauge

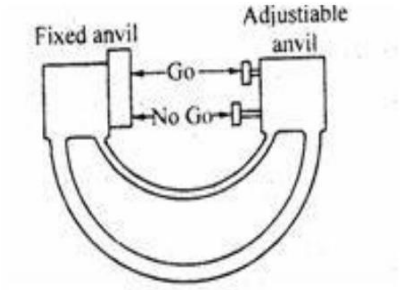
This type of snap gauge is also called caliper gauge. It is mainly used for checking large diameters up to 100mm. Both GO and NOGO anvils at the same end.

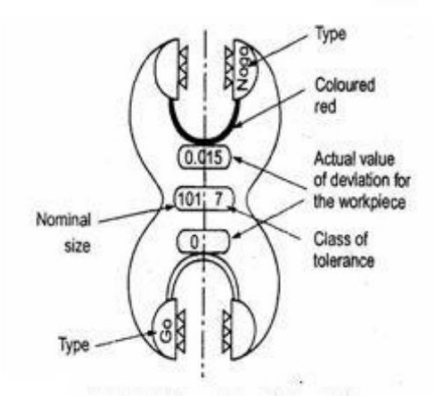
The GO anvil should be at the front and NOGO anvil at the rear. So, the diameter of the shaft is checked progressively by these two ends. This type of gauge is made of horse shoe shaped frame with I section to reduce the weight of the snap gauges.

Adjustable Snap Gauge

Adjustable snap gauges are used for checking large size shafts made with horse shoe shaped frame of I section. It has one fixed anvil and two small adjustable anvils. The distance between the two anvils is adjusted by adjusting

the adjustable anvils by means of set screws. This adjustment can be made with the help of slip gauges for specified limits of size.





Combined Limit Gauges

A spherical projection is provided with GO and NOGO dimension marked in a single gauge. While using GO gauge the handle is parallel to axes of the hole and normal to axes for NOGO gauge.

Position Gauge

It is designed for checking the position of features in relation to another surface. Other types of gauges are also available such as contour gauges, receiver gauges, profile gauges etc.

12. 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)

VERNIERCALIPERS

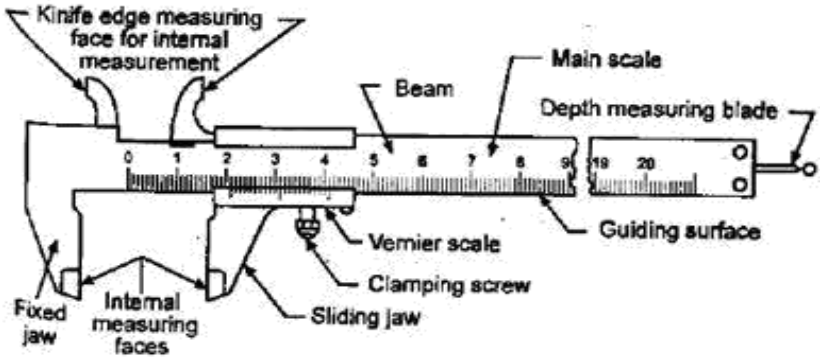
The vernier instruments generally used in workshop and engineering metrology have comparatively low accuracy. The line of measurement of such instruments does not coincide with the line of scale. The accuracy therefore depends upon the straightness of the beam and the squareness of the sliding jaw with respect to the beam.

To ensure the squareness, the sliding jaw must be clamped before taking the reading. The zero error must also be taken into consideration. Instruments are now available with a measuring range up to one meter with a scale value of 0.1 or0.2 mm.

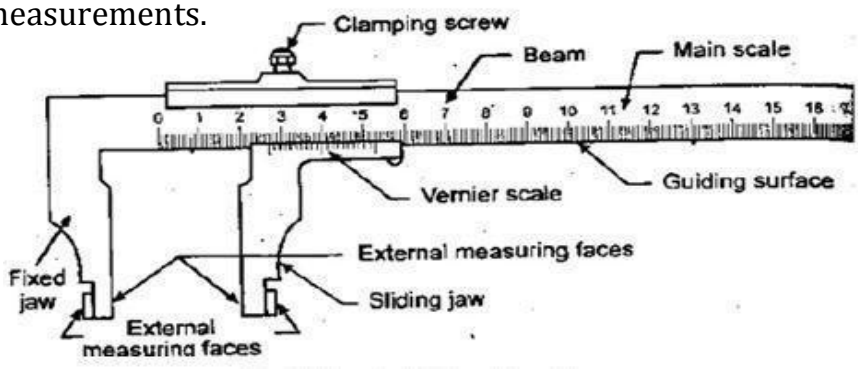
Types of Vernier Calipers

According to Indian Standard IS:3651- 1974, three types of vernier calipers have been specified to make external and internal measurements and are shown in figures respectively. All the three types are made with one scale on the front of the beam for direct reading.

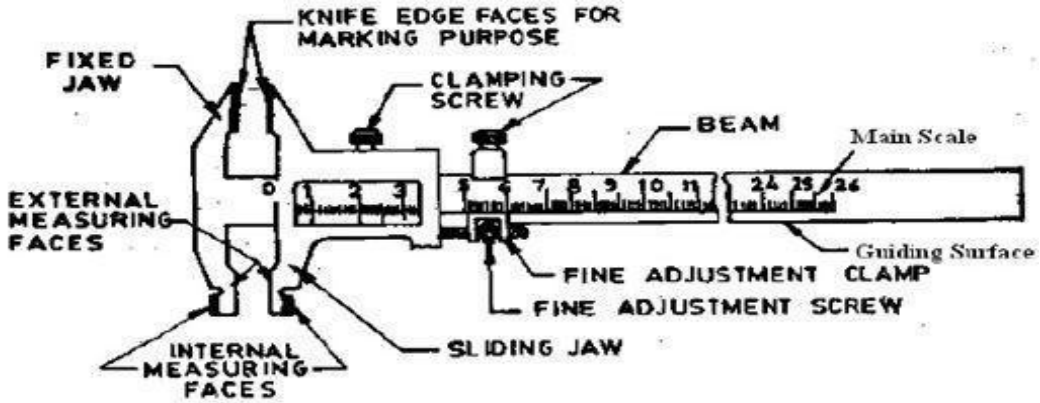
TypeA : Vernier has jaws on both sides for external and internal measurementsand a blade for depth measurement.



Type B: It is provided with jaws on one side for external and internalmeasurements.



Type C: It has jaws on both sides for making the measurement and for markingoperations

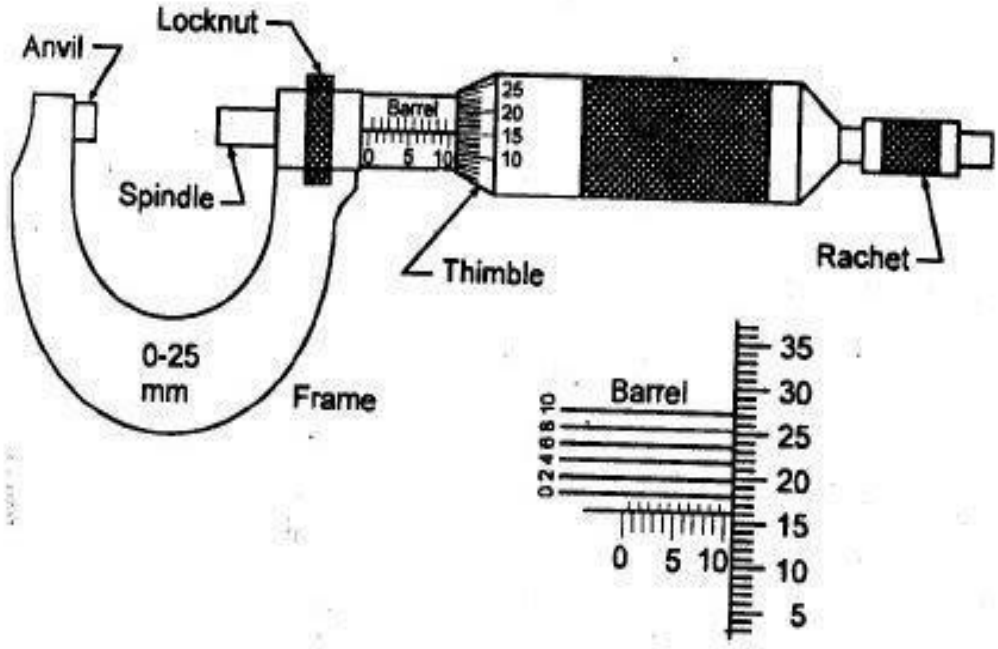


MICROMETERS

There are two types in it.

- Outside micrometer— To measure external dimensions.
- Inside micrometer—To measure internal dimensions

An outside micrometer is shown. It consists of two scales, main scale and thimble scale. While the pitch of barrel screw is 0.5mm the thimble has graduation of 0.01mm. The **least count** of this micrometer is 0.01 mm.



The micrometer requires the use of an accurate screw thread as a means of obtaining a measurement. The screw is attached to a spindle and is turned by movement of a thimble or ratchet at the end. The barrel, which is attached to the frame, acts as a nut to engage the screw threads, which are accurately made with a pitch of 0.05mm. Each revolution of the thimble advances the screw 0.05mm. On the barrel a datum line is graduated with two sets of division marks.

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

COMPARATORS

Comparators are one form of linear measurement device which is quick and more convenient for checking large number of identical dimensions. Comparators normally will not show the actual dimensions of the work piece. They will be shown only the deviation in size.

During the measurement a comparator is able to give the deviation of the dimension from the set dimension. This cannot be used as an absolute measuring device but can only compare two dimensions. Comparators are designed in several types to meet various conditions.

Comparators of every type in corporate some kind of magnifying device. The magnifying device magnifies how much dimension deviates, plus or minus, from the standard size.

The comparators are classified according to the principles used for obtaining magnification. The common types are:

1) Mechanical comparators
2) Electrical comparators
3) Optical comparators
4) Pneumatic comparators

MECHANICAL COMPARATORS

Mechanical comparator employs mechanical means for magnifying small deviations. 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.

Mechanical comparators are available having magnifications from 300 to 5000 to 1. These are mostly used for inspection of small parts machined to close limits.

Dial indicator

A dial indicator or dial gauge is used as a mechanical comparator. The essential parts of the instrument are like a small clock with a plunger projecting at the bottom as shown in fig.

Very slight upward movement on the plunger moves it upward and the movement is indicated by the dial pointer. The dial is graduated into 100 divisions.

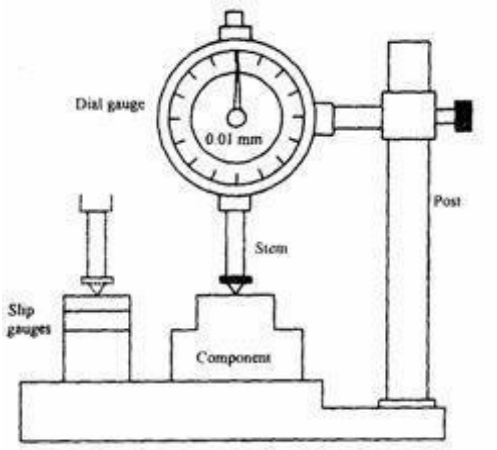
A full revolution of the pointer about this scale corresponds to1mm travel of the plunger. Thus, a turn of the pointer b one scale division represents a plunger travel of 0.01mm.

Experimental setup

The whole setup consists of worktable, dial indicator and vertical post. The dial indicator is fitted to vertical post by on adjusting screw as shown in fig. The vertical post is fitted on the worktable; the top surface of the work table is finely finished. The dial gauge can be adjusted vertically and locked in position by a screw.

Procedure

Let us assume that the required height of the component is 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.

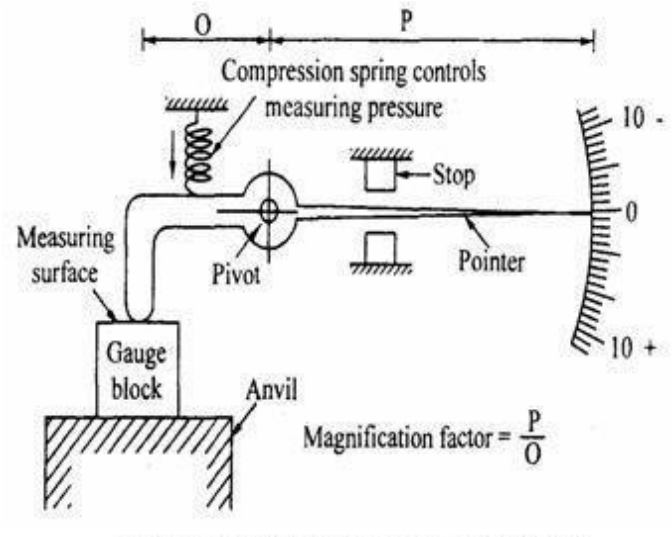


Now the component to be checked is introduced under the stem of the dial gauge. If there is any deviation in the height of the component, it will be indicated by the pointer.

Mechanism

The stem has rack teeth. A set of gears engage with the rack. The pointer is connected to a small pinion. The small pinion is independently hinged. i.e. .it is not connected to the stern. The vertical movement of the stem is transmitted to the pointer through a set of gears. A spring gives a constant downward pressure to the stem.

READ TYPE MECHANICAL COMPARATOR



In this type of comparator, the linear movement of the plunger is specified by means of read mechanism. The mechanism of this type is illustrated in fig. A spring- loaded pointer is pivoted. Initially, the comparator is set with the help of a known dimension eg. Set of slip gauges as shown in fig. Then the indicator reading is adjusted to zero. When the part to be measured is kept under the pointer, then the comparator displays the deviation of this dimension either in ± or — side of the set dimension.

Advantages

- It is usually robust, compact and easy to handle.
- There is no external supply such as electricity, air required.

- It has very simple mechanism and is cheaper when compared to other types.
- It is suitable for ordinary workshop and also easily portable.

Disadvantages

- Accuracy of the comparator mainly depends on the accuracy of the rack and pinion arrangement. Any slackness will reduce accuracy.
- It has more moving parts and hence friction is more and accuracy is less.
- The range of the instrument is limited since pointer is moving over a fixed scale.

OPTICAL COMPARATOR

In this type of comparator, small plunger displacement is amplified by both mechanical and optical system. The amplification is first done by pivoted lever and then by a simple optical systems.

Construction details

The optical comparator consist of the following parts such as

(1) Pivoted lever
(2) Objective lens
(3) Scale
(4) Plunger
(5) Table and base
(6) Mirror

Pivoted lever

The pivoted lever amplifies the plunger movement mechanically .It is pivoted near the plunger. One end is fitted with the plunger and other end is fitted with a mirror.

Objective lens

The main function of objective lens is to convert the incoming light rays from the source into parallel beams

Screen and scale

It is final display device from which the readings can be obtained.It is semi transparent glass

Plunger

It is reciprocating member. During the measurement, the plunger actuates.

Table

The work is palced on the table to carry out the task.

Base

It is rigid support over which the table is mounted

Mirror

It reflects the incoming light rays from the source which is hinged at the other end of the lever.

Working Principle

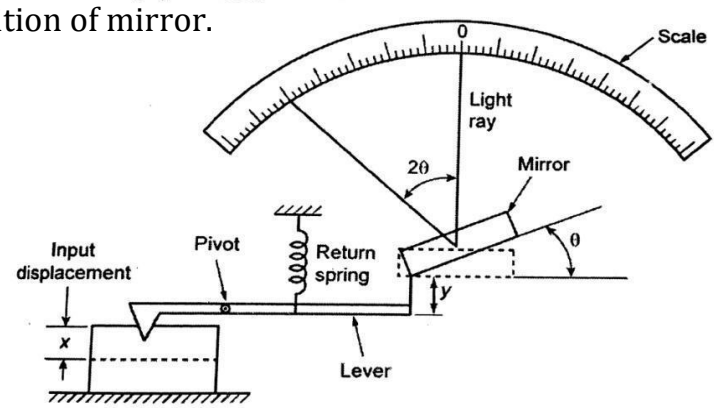
During measurement, the vertical displacement of the plunger is magnified by the ratio of the lever arm. The lever title the mirror about its hinged to again magnify. The light rays from the lamp are condensed by a condensing less. Then, the condensed light falls on the objective lens. The light rays are converted into parallel beams again the parallel beam of light ray fall on the mirror.

The mirror reflects the light rays on a screen As the screen is the semi transparentglass ,the image of work placed on the table will be reflected. The magnified master drawing is placed over the screen. The projected image is compared with the master drawing .This type of comparator can also used for inspecting small Parts such as screw, thread, saw teeth etc

The differences amplified by a lever to give a vertical displacement and an angular displacement .The difference x between two dimension may be used to actuate a lever to displace by y .same displacement causes a ray of light which is initially at zero angle to get displaced by 2 because the mirror is deflected by .The magnified reading is a measure of displacement x. the scale is calibrated by gauge blocks.

Advantages

- Small parts can also be inspected
- Different amplification can be obtained by adjuisting the projection lens and the position of mirror.



Pneumatic Comparator

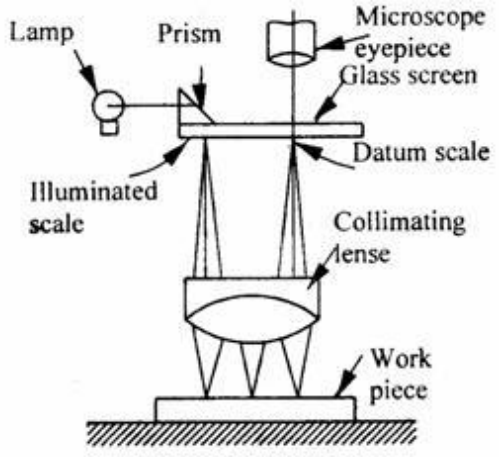
In this system, no physical contact is made either with the setting gauge or the part being measured, and that internal dimensions may be readily measured, not only with respect to tolerance boundaries, but also geometric form. Further, the system lends itself to the inspection of a single, or a number of dimensions simultaneously, either during or immediately after the operating cycle of a machine tool.Back-pressure (Pneumatic) comparator: It uses a water manometer for the indication of back pressure.

It consists of a vertical metal cylinder filled with water upto a certain level and a dip tube immersed into it upto a depth corresponding to the air pressure required. A calibrated manometer tube is connected between the cylinder and control orifice as shown in fig.. The air from its normal source of supply is filtered and passes through a flow valve.

Its pressure is then reduced and maintained at a constant value by a dip tube into a water chamber, the pressure value being determined by the head of the water displace, excess air escaping to atmosphere. The air at reduced pressure then passes through the control orifice, and escapes from the measuring orifice. The back pressure in the circuit is indicated by the head of water displaced in the manometer tube.

The tube is graduated linearly to show changes of pressure resulting from changes in dimension‘d’. Amplifications of up to 50000 are obtainable with this system.

14. 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)



This is also a type of auto -collimator. There is an illuminated scale in the focal plane of the collimating lens.

This illuminated scale is projected as a parallel beam by the collimating lens which after striking a reflector below the instrument is refocused by the lens in the field of view of the eyepiece. In the field of view of microscope, there is another datum scale fixed across the center of screen.

The reflected image of the illuminated scale is received at right angle to the fixed scale as shown in fig. Thus the changes in angular position of the reflector in

two planes are indicated by changes in the point of intersection of the two scales. One division on the scale is calibrated to read1minute.

Uses of Angle Dekkor

Measuring angle of a component

Angle dekkor is capable of measuring small variations in angular setting i.e. determining angular tilt. Angle dekkor is used in combination with angle gauge. First the angle gauge combination is set up to the nearest known angle of the component.

Now the angle dekkor is set to zero reading on the illuminated scale. The angle gauge build up is then removed and replaced by the component under test.

Usually a straightedge being used to ensure that there is no change in lateral positions. The new position of the reflected scale with respect to the fixed scale gives the angular tilt of the component from the set angle.

Checking the slope angle of a V-block

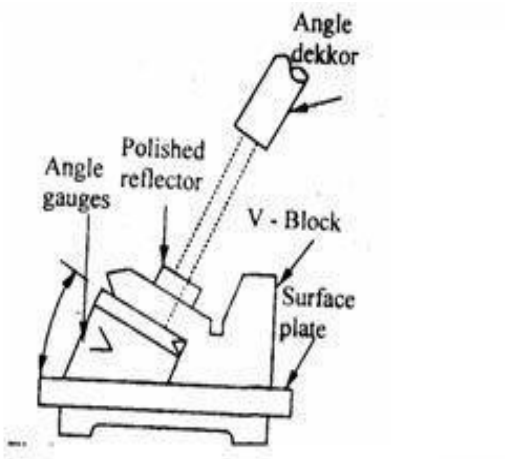


Figure shows the setup for checking the sloping angle of V block. Initially, a polished reflector or slip gauge is attached in close contact with the work surface. By using angle gauge zero reading is obtained in the angle dekkor. Then the angle may be calculated by comparing the reading obtained from the angle dekkor and angle gauge.

To measure the angle of cone or Taper gauge

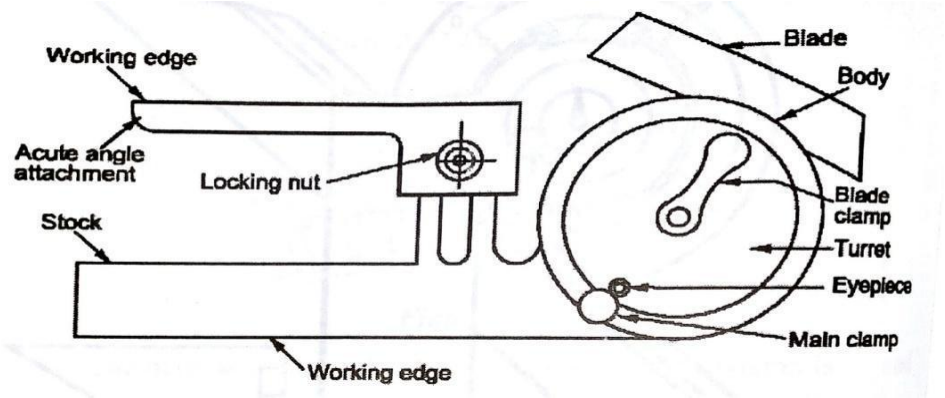
Initially, the angle dekkor is set for the nominal angle of cone by using angle gauge or sine bar. The cone is then placed in position with its base resting on the surface plate. A slip gauge or reflector is attached on the cone since no reflection can be obtained from the curved surface. Any deviation from the set angle will be noted by the angle dekkor in the eye piece and indicated by the shifting of the image of illuminated scale.

OPTICAL BENVEL PROTRACTOR

Working Principle

The value can be measured to an accuracy of 2 min by using this type of bevel protractor .The values are obtained against an index line or vernier by means of an optical magnifying system .The optical magnifying system is attached with the bevel protractor itself.

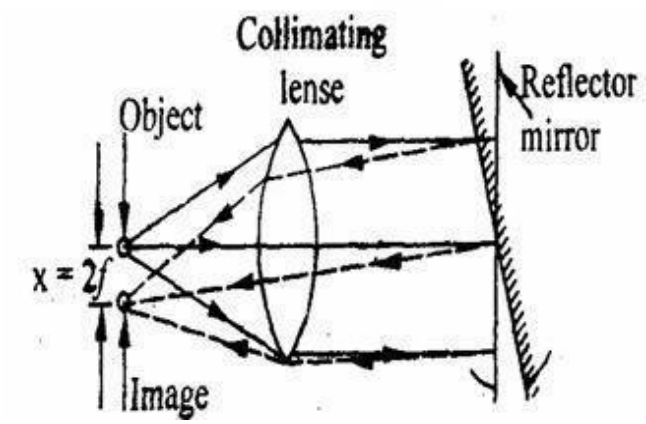
A separate arrangement is provided for adjusting the focus of the system for the normal variation of eye sight .The vernier scale are arranged always in focus of the optical system.



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

AUTO- COLLIMATOR

Auto-collimator is an optical instrument used for the measurement of small angular differences, changes or deflection, plane surface inspection etc. For smallangular measurements, autocollimator provides a very sensitive and accurate approach. An auto-collimator is essentially an infinity telescope and a collimator combined into one instrument.



Basic principle

If a light source is placed in the flows of a collimating lens, it is projected as a parallel beam of light. If this beam is made to strike a plane reflector, kept normal to the optical axis, it is reflected back along its own path and is brought to the same focus. The reflector is tilted through a small angle '0'. Then the parallel beam is deflected twice the angle and is brought to focus in the same plane as the light source.

The distance of focus from the object is given

$$x = 2\theta \, . f$$

Where, f = Focal length of the lens

by θ = Fitted angle of reflecting mirror.

WORKING OF AUTO-COLLIMATOR:

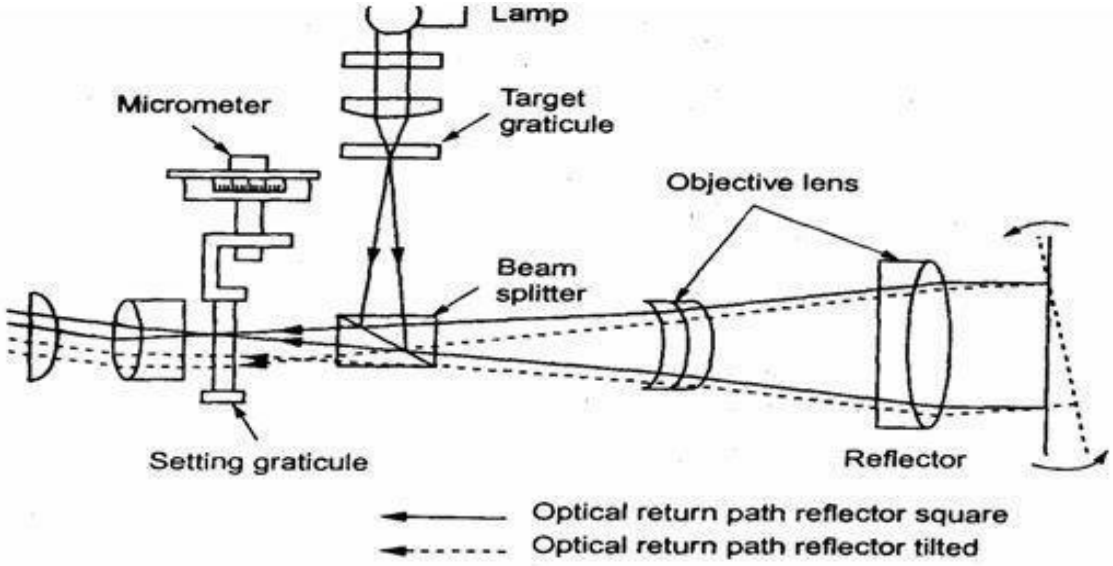
There are three main parts in auto-collimator.

1. Micro meter microscope.

2. Lighting unit and

3. Collimating lens.

Figure shows a line diagram of a modern auto - collimator. A target graticule is positioned perpendicular to the optical axis. When the target graticule is illuminated by a lamp, rays of light diverging from the intersection point reach the objective lens via beam splitter. From objective, the light rays are projected as a parallel rays to the reflector.



A flat reflector placed in front of the objective and exactly normal to the optical axis reflects the parallel rays of light back along their original paths. They are then brought to the target graticule and exactly coincide with its intersection. A portion of the returned light passes through the beam splitter and is visible through the eyepiece. If the reflector is tilted through a smallangle, the reflected beam will be changed its path at twice the angle. It can also be brought to target graticule but linearly displaced from the actual target by the amount 2θxf. Linear displacement of the graticule image in the linear displacement of the graticule image in the plane tilted angle of eye piece is directly proportional to the reflector. This can be measured by optical micrometer. The photo electric auto-collimator is particularly suitable for calibrating polygons, for checking angular indexing and for checking small linear displacements.

APPLICATIONSOFAUTO-COLLIMATOR

Auto-collimators are used for

1) Measuring the difference in height of length standards.

2) Checking the flatness and straightness of surfaces.

3) Checking squareness of two surfaces.

5) Precise angular indexing in conjunction with polygons.Checking alignment or parallelism.

6) Comparative measurement using master angles.

7) Measurement of small linear dimensions.

8) For machine tool adjustment testing.

Part C

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

Sine bars are always used along with slip gauges as a device for the measurement of angles very precisely.

They are used to

- Measure angles very accurately.
- Locate the work piece to a given angle with very high precision.

sinebars are made from high carbon, high chromium ,and corrosion resistant steel. These materials are highly hardened, ground and stabilized. Insinebars, two cylinders of equal diameter are attached at lie ends with its axes are mutually parallel toeachother.Theyarealsoatequaldistancefromtheuppersurfaceofthesinebar mostly the distance between the axes of two cylinders is 100mm, 200mm or 300mm.The working surfaces of the rollers are finished to 0.2μmR value. The cylindrical lholes are provided to reduce the weight of the sinebar

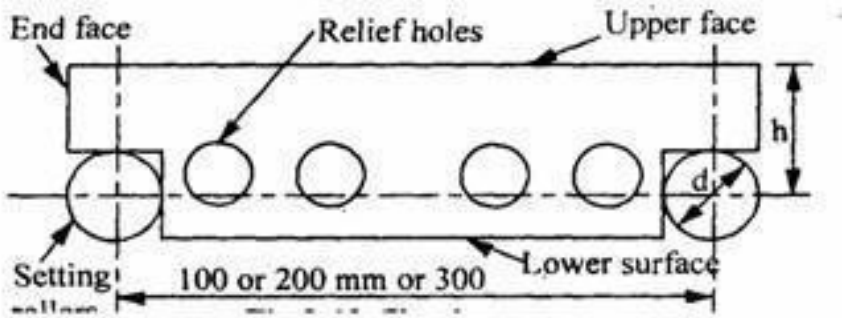


Fig 2.21 Sine Bar

Working principle of sinebar

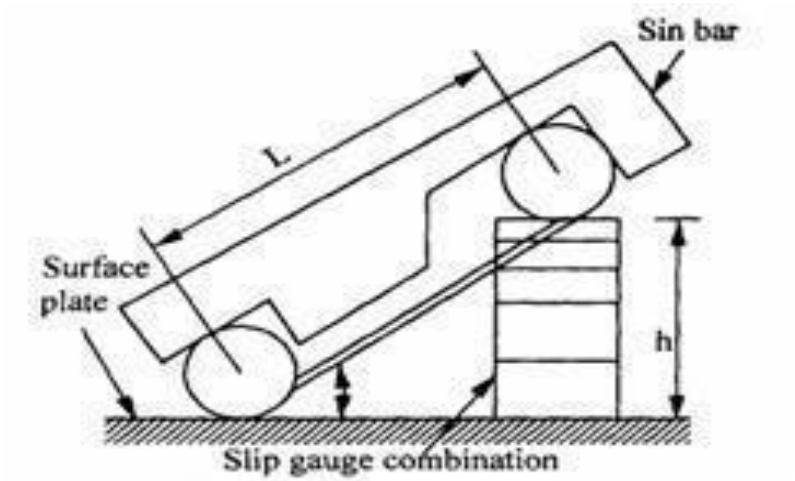


Fig 2.22 Principle of Sine bar

The working o fsinebar is based on**trigonometryprinciple**.Tomeasurethe angle of a given specimen,one roller of the sinebar is placed on the surface plate and another one roller is placed over the surface of slip gauges. Now, 'h' be the height of the slip gauges and 'L' be the distance between roller centers,

$$\text{Sin}\theta = \frac{h}{L}$$

$$\therefore \theta = Sin^{-1}(h/L)$$