

ME-6504 METROLOGY & MEASUREMENTS

PART A QUESTIONS WITH ANSWERS

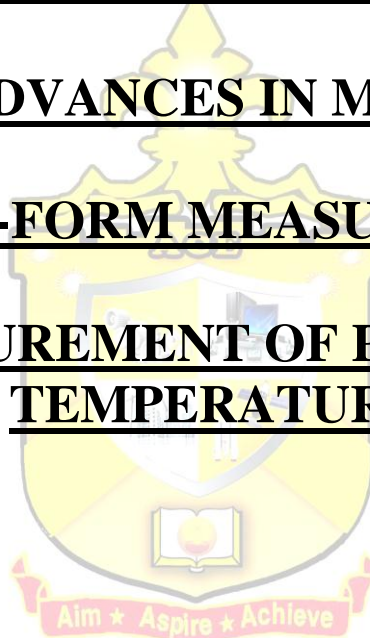
UNIT 1- INTRODUCTION TO METROLOGY

UNIT 2- LINEAR & ANGULAR MEASUREMENTS

UNIT 3- ADVANCES IN METROLOGY

UNIT 4-FORM MEASUREMENT

**UNIT 5- MEASUREMENT OF POWER , FLOW &
TEMPERATURE**



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METROLOGY & MEASUREMENTS

UNIT I- BASICS OF METROLOGY

1. What is Range of measurement ?

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

2. What is Resolution?

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

3. Define sensitivity.

It 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 the instrument responds.

4. Define error and correction.

Error: The difference 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 legal Metrology.

Legal metrology is part of Metrology and it is directed by a National Organisation which is called “National Service of Legal Metrology”

7. Define over damped and under damped system

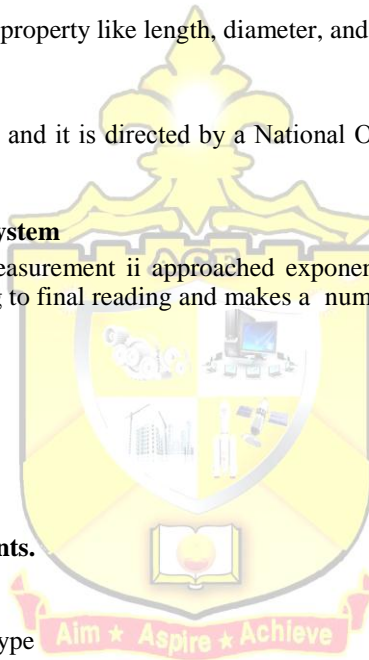
Over damped - The final indication of measurement is approached exponentially from one side. Under damped - The pointer approaches the position corresponding to final reading and makes a number of oscillations around it.

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. Deflection & Null type
2. Active & Passive type
3. Contacting & Non contacting type
4. Intelligent type



10. Define True size & Actual size

True size is theoretical size of object.

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 – ability of the an instrument to respond to a true value of a measured variable under the reference conditions. It refers how closely the measured value agrees with the true value.

Example: Measuring accuracy is $\pm 0.02\text{mm}$ for diameter 25mm.

Here the measurement true values lie between 24.98 to 25.02 mm

Uncertainty casts a doubt about the exactness of the measurement results . It is an expression of the fact that for a given result of measurement , there is not one value but infinite number of values dispersed about the result with varying degree of credibility.

14. Define Span

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

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

15 Differentiate between precision and accuracy.

Accuracy – ability of an instrument to respond to a true value of a measured variable under the reference conditions. It refers how closely the measured value agrees with the true value.

Precision - Degree of repetitiveness. It refers to the ability of the instrument to reproduce its readings again and again in the same manner for constant input signal

16. What is Static and dynamic response ?

Static characteristics of an instrument are considered which are used to measure an unvarying process conditions.

Dynamic response is the behavior of an instrument under time varying input-output conditions.

17. What is Response ?

It is defined as the rapidity with which a measurement system responds to the change in the measured quantity

18. Define Repeatability:

The ability of the measuring instrument to repeat the same results of 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 Measurements
2. Commercial transactions
3. Public health and human safety ensuring.

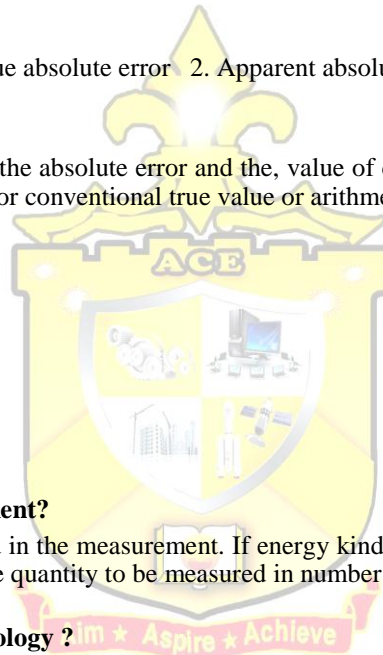
24. What is the need of inspection ?

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

25. What are the important elements of measurement process?

The important elements of a measurement is

1. Measurand
2. Reference
3. Comparator



UNIT II – LINEAR AND ANGULAR MEASUREMENTS

1. 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.

2. How do you calibrate the slip gauges?

Comparators are used to calibrate the slip gauges.

3. 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. Comparators

4. 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

5. What are comparators?

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

6. 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.

7. 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.

8. State the best example of a mechanical comparator.

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

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

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

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

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.

11. 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.

12. 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.

13. What are the parts of an electrical comparator?

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

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

14. On what basis the transducer of electrical comparator 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.

15. 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.

16. 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.

17. Mention the important parts of an electronic comparator.

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

18. Classify pneumatic comparators.

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

19. 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.

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

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

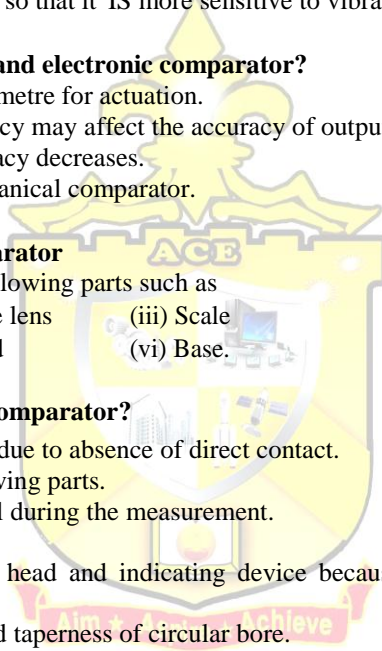
21. List the various parts of an optical comparator

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.

22. What are the advantages of pneumatic comparator?

- (i) The wear of measuring heads is avoided due to absence of direct contact.
- (ii) Friction is less due to less number of moving parts.
- (iii) Work piece is cleaned by supplying of air during the measurement.
- (iv) 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) It is a suitable method to check ovality and taperness of circular bore.



UNIT-3 ADVANCES IN METROLOGY

1. What is interferometer? Define Wavelength.

Interferometer is optical instruments used for measuring flatness and determining the lengths of slip gauges by direct reference to the wavelength of light. The distance between two crest or two trough is called the wavelength

2. State the principle of Interferometry.

Two light rays from the same monochromatic light source can be combined to give a bright or dark surface by changing the phase difference between them. The brightness or darkness can then be a measure of displacement.

3. What are the characteristics of the Laser ?

- Monochromatic light source.
- Directional possibility
- Coherent light rays

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

Straightness , Flatness , Parallelism, equidistance and coincidence of the slide ways , Squareness of straight line & plane , movement of all working components

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

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

6. What is the advantage of using laser beam interferometry?

Laser provides a source of coherent and truly monochromatic light. The property of clearance enables it to be projected in a narrow pencil of beam without any scatter.

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

1. Straightness. 2. Flatness. 3. Parallelism, 4. equi-distance and coincidence.

8. What is the principle of laser?

The photon emitted during stimulated emission has the same energy, phase and frequency as the incident photon.

This principle states that the photon comes in contact with another atom or molecule in the higher energy level E_2 then it will cause the atom to return to ground state energy level E_1 , by releasing another photon.

The sequence of triggered identical photon from stimulated is known as stimulated emission. This multiplication of photon through stimulated emission' leads to coherent, powerful, monochromatic, collimated beam of light emission. This light emission is called laser.

9. What is CMM?

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

10. Mention the types of CMM.

Cantilever , Bridge , Vertical bore & Horizontal bore type.

11. Explain CNC, CMM briefly.

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

12. Write some features of CMM software.

- Measurement of diameter, center distance can be measured as follows.
- Measurement of plane & spatial curves.
- Minimum CNC programme.
- Data communications.
- Digital input & output command.
- Interface to CAD software.

13. Define machine vision.

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

14. What are the basic types of machine vision system ?

- Image formation.
- Processing of image.
- Analyzing the image.
- Interpretation of image.

15. What are the advantages of Machine vision system?

- Reduces the tooling & fixture cost.
- It eliminates the need for precise part location.
- It integrates the automation of dimensional verification.
- It helps to detect the defects.

16. Define gray scale analysis.

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

17. Mention the advantages of CMM.

- Inspection rate is increased.
- Improved accuracy of machined parts is obtained.
- Minimizes the operator error.
- Skill requirements of the operator are reduced.
- Uniform inspection quality is ensured.
- Reduces setup time.

18. Define straightness of axes.

Straightness is a condition where an element of a surface or an axis is a straight line.

Straightness is defined as the deviation from a straight line in 2 orthogonal planes for each axis movement and six measurements to be considered. Straight lines of x-axis are measured in y & z direction , y-axis in x & z direction , z-axis in x & y directions.

19. Mention the applications of CMM.

- It finds the applications in automatic , machine tool , electronics, space & many other large companies.
- Ideally suited for the development of new products & construction of prototype.
- Very much useful in checking NC produced work piece in various steps of production.
- For aircraft & space 100% inspection is carried out by using CMM.

20. Mention the disadvantages of CMM.

- The table and probe may not be in perfect alignment.
- The stylus may have run out.
- The stylus moving in z-axis may have some perpendicularity errors.
- Stylus while moving in x and y direction may not be square to each other.
- There may be errors in digital system

UNIT 3 FORM MEASUREMENT

1. Name the various types of pitch errors found in screw.

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

2. Name the various methods of measuring the minor & major diameter of the thread.

- Minor diameter - Using taper parallels , rollers & slip gauges
- Major diameter – Ordinary micrometer & Bench micrometer.

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

(i) Ordinary micrometer (ii) Bench micro meter

4. Define effective diameter. Mention the methods of measuring effective diameter.

- Effective diameter is the average of major & minor diameter of the thread
- (i) One wire method (ii) Two wire method (iii) Three wire method.

5. Name the various methods for measuring pitch diameter.

(i) Pitch measuring machine (ii) Tool maker's microscope (iii) Screw pitch gauge.

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

rake corrections & Compression correction

7. What is best size of wire?

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

8. Define drunken thread

This is one, having erratic pitch, in which the advance of the helix is irregular in one complete revolution of thread.

9. What are the applications of toolmaker's microscope?

(i) Linear measurement (ii) Measurement of pitch of the screw (iii) Measurement of thread angle.

10. Define Lead & Lead angle.

- Lead : It is defined as the distance at which a thread advances for one rotation.
- Lead angle : It is defined as the angle between the tangent to the helix and plane perpendicular to the axis of cylinder.

11. What are the commonly used forms of gear teeth? Mention the type of gears

- Involute
- Cycloidal
- Spur , Helical , bevel , Worm & Worm wheel , Rack & Pinion.

12. What are the various methods used for measuring the gear tooth thickness?

(i) Gear tooth vernier (ii) Constant chord method (iii) Base tangent method (iv) Measurement over pins.

13. Name four gear errors.

Pitch error , Alignment error , Composite error & Thickness error

14. What are the direct angular measurements methods?

Profile checking : a) Optical projection method b) Involute measuring method.
Thickness measurement : a) Chordal thickness method b) Constance chord method.

15. Define : constant chord

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

16. Define fullness and emptiness in form factor.

Degree of fullness (K) = area of metal /Area of enveloping rectangle
Degree of emptiness = 1 - K

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

a) Inspection by comparison b) Direct instrument measurements.

18. What are the stylus probe instruments?

a) Profilo meter b) Taylor Hobson Talysurf c) Tomlinson surface meter

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

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

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

It is a surface of revolution where all the surfaces intersected by any plane perpendicular to a common axis in case of, cylinder and cone.

a. Heart square circle. b. Minimum radial separation circle. c. Maximum inscribed circle. d. Minimum circumscribed circle.

21. Name the devices used for measurement of roundness.

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

22. Define gear run out.

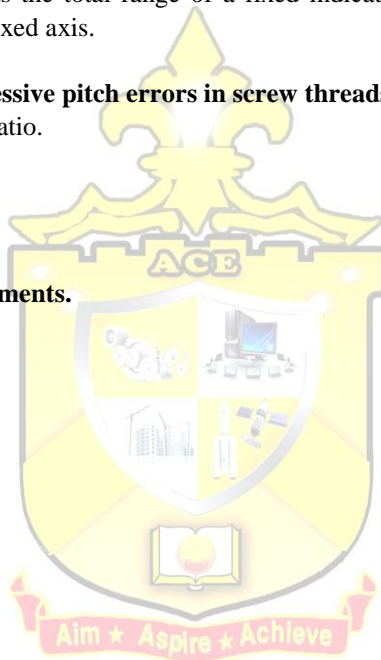
It means eccentricity in the pitch circle. It will produce periodic vibration during each revolution of the gear. It will give the tooth failure in gears. It is also defined as the total range of a fixed indicator with the contact points applied to a surface rotated without axial movements about a fixed axis.

23. List the reasons for occurrence of progressive pitch errors in screw threads.

- Incorrect linear and angular velocity ratio.
- Incorrect gear train & Lead screw.
- Saddle fault.
- Variation in length due to hardening.

24. Mention the various Spur Gear measurements.

- Run out
- Pitch
- Profile
- Lead
- Back lash
- Tooth thickness
- Concentricity
- Alignment.



UNIT 5 – MEASUREMENT OF POWER, FLOW AND TEMPERATURE

1. What are load cells? Mention its functions.

Load cells are devices for the measurement of force through indirect methods. Force is applied to elastic member of the cell results in a proportional displacement or strain sensed by calibrated mechanical or electrochemical means.

2. Give the principle of hot wire anemometer

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

3. Name any four inferential type of flow meters

- Venturi meter,
- orificemeter,
- rotameter,
- pitot tube.

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

In fluid expansion thermometers, the change in pressure in the bulb is taken as an indication of the temperature.

5. Mention the principle involved in bimetallic strip.

Two pieces of metal with different conditions of thermal expansion are bonded together to form the bimetallic strip. It is in the form of cantilever beam. When the strip is subjected to a temperature higher than the bonding temperature, it will bent in one direction.

6. What is thermocouple?

Thermocouple is most common method of temperature measurement which uses the principle of “SEEBACK” effect, which is stated as “When two dissimilar metals are joined together an emf will exist between two points A & B which is primarily a function of the junction temperature”.

7. What is a Kentometer?

It is a device for measurement of absolute pressure.

8. What is thermopile?

When thermocouples are connected in series to measure the temperature, it is called thermopile

9. Give the classification of temperature measuring methods.

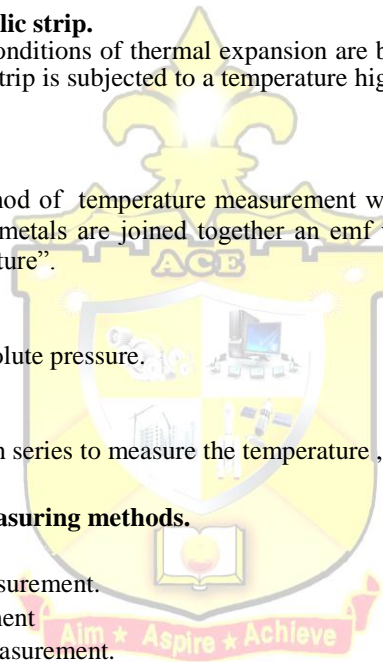
- Gas filled temperature measurement.
- Electrical resistance temperature measurement.
- Thermocouple temperature measurement
- Semiconductor based temperature measurement.

10. List the instruments used for measuring temperature.

- Thermocouple (thermopile)
- Electrical thermal resistance
- Thermistors
- Pyrometers.

11. What are the physical characteristics of temperature measuring sensor?

- Accuracy
- Discrimination
- Precision
- Errors
- Drift
- Sensitivity
- Linearity
- Hysteresis.



12. What are the laws of thermocouples?

- Law of intermediate metals : If a third metal is introduced into a thermopile circuit , the net emf of the circuit is not affected as long as the new connections are at the same temperature.
- Law of intermediate temperature : In a thermocouple circuit , an emf E_1 will be produced if the junction temperatures are maintained at T_1 & T_2 . An emf E_2 will be produced when junctions are at temperatures T_2 & T_3 . According to the law of temperature , the same circuit will produce an emf E_3 (E_2+E_3) when operating between temperature T_1 & T_2 .

13. Mention the composition of thermocouple alloys.

- Alumel : 94% Nickel , 3% Manganese , 2% Aluminium & 1% Silicon.
- Constantan : 55% Copper & 45% Nickel
- Chromel : 90% Nickel & 10% Chromium.

14. List out the common thermocouple materials used.

- Constantan
- Alumel
- Chromel
- Copper
- Platinum
- Rhodium
- Iron

15. What is meant by thermistor ?

- The thermistor is a semiconductor device which has a negative temperature coefficient of resistance.
- Thermistors are non-metallic resistors which mean semiconductors of ceramic materials.

16. Give the principle of electrical resistance thermistor.

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

17. Mention the differences between Orifice meter & Venturi meter.

- Orifice meter : Loss of head is small , No wear & tear , Initial cost is more & Less space compared with Venturi meter
- Venturimeter : Loss of head is more , Wear & tear more , Low initial cost & . Requires more space.

18. List out the types of Power measurement methods.

- Absorption dynamometers
- Driving dynamometers
- Transmission dynamometers

19. What is meant by Pyrometer? Mention its types

- Pyrometer is temperature measurement device which is based on the principle of change in intensity & colour of thermal radiation emitted by a body.
- Types : Total radiation pyrometer , Infra red pyrometer & Optical radiation pyrometer.

20. Mention the different types of Flow measurement devices.

- Venturimeter
- Orifice meter
- Pitot tube
- Rotameter
- Hot wire anemometer
- Magnetic flow meter

