IV/IV B.Tech Regular/Supplementary Degree Examination
JANUARY, 2021
(First Semester)
ENGINEERING METROLOGY& MECHANICAL MEASUREMENTS
(MECHANICAL ENGINEERING)

SCHEME OF EVALUATION

PART- A

1.

a) What do you understand by line and end standard? (Any TWO)

S.No	**Characteristics**	**Line**	**End**
1	Principle	Length is expressed as distance between two lines.	Length is expressed as distance between two parallel faces.
2	Accuracy	Limited to ±0.2 mm	High accuracy of about ± 0.0001 mm
3	Ease and Time of measurement	Quick and easy	Requires skill and time consuming
4	Effect of wear	Less	Subjected to wear on measuring faces
5	Alignment	Not easily aligned with the axis of measurement	Can be easily aligned with the axis of measurement
6	Manufacture and cost	Simple to manufacture at low cost	Manufacturing process is complex and high cost
7	Parallax error	Yes	No
8	Example	Scale	Slip gauges, V. Calipers

b) Differentiate tolerance and allowance. (ANY TWO)

S.No	Tolerance	Allowance
1	Permissible variation in dimensions of a part.	Prescribed difference b/w two mating parts.
2	Difference of higher and lower limits of a part.	Difference b/w lower limit of a hole and higher limit of a shaft.
3	Provided since it is not possible to make part to its exact size.	Provided to get the required fit.
4	It is absolute value without sign.	It may be positive or negative.

c) Explain Taylor’s Principle of gauge design.

It states that

A) GO →MML; NO-GO →LML

B) Go gauge should check all the related dimensions at a time where as the No-Go gauge should check only one dimension i.e. LML at a time.

d) Explain working of spirit levels.

A calibrated spirit level is an angular measuring device of great precision. It is simply a glass tube, the bore of which is ground to a large radius.

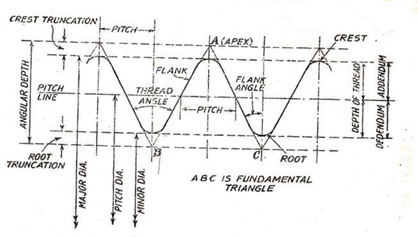
The liquid almost fills the tube, the bubble always lie in the highest position of the tube.

If the tube is tilted through a small angle, the bubble will move along the radius of the tube through a certain distance depending upon the angle of tilt.

e) Differentiate primary and secondary texture.

S. No.	Primary Texture or Roughness	Secondary Texture or Waviness
1	Micro geometrical irregularities	Macro geometrical irregularities
2	Constitutes Third and Fourth order irregularities	Constitutes First and Second order irregularities
3	$\frac{h_r}{l_r} > 50$	$\frac{h_w}{l_w} < 50$

f) Name the important elements of screw thread.



Screw-thread terms relating to external thread.

g) What are the static performance characteristics of a measurement system?(Any Two)

Range, span, error, correction, sensitivity, calibration, resolution, dead zone, hysteresis, precision, accuracy.

h) What is the purpose of strain rosette?

Multiple grid or rosettes are group of gauges bonded to the same supporting material in definite relative positions for measuring strains.

i) Write explanatory notes on Hot-wire anemometer.

It is used for measuring the flow rate of air. This is based on a heated element from which the heat is extracted by the colder air flow. This causes the change in resistance of the element. The change in resistance is measured in terms of voltage drop across the Wheatstone bridge and the deflection of Wheatstone bridge provides the flow rate of the air.

j) Classify pressure measurement techniques.

a. Instruments for measuring low pressures (below 1mm of Hg): Manometers and Low pressure gauges
b. Instruments for measuring medium and high pressures (between 1mm of Hg to 1000 atmospheres) : Bourdon tube and Diaphragm gauges
c. Instruments for measuring low vacuum and ultra-high vacuum (760 torr to 10^{-9} torr): McLeod, Thermal conductivity and ionization gauges.

d. Instruments for measuring very high pressures (1000 atmospheres and above): Bourdon Tube, Diaphragm and electrical resistance pressure gauges.
e. Instruments for measuring varying pressure: Engine indication and Cathode Ray Oscilloscope.

k) Explain principle of thermistors.

Thermistor is a contraction of the name “Thermal Resistor”. They are essentially semiconductors which behave as resistors with a high negative temperature coefficient. As the temperature increases, the resistance goes down and as the temperature decreases, the temperature goes up.

l) Define load cell and state its applications.

It is a device which converts the force acting on it into another form of physical quantity for measuring the intensity of load.

PART-B

2.

a. Differentiate i. Unilateral and Bilateral tolerances; ii. Clearance and interference fits; iii. Tolerance and allowance. (Diagram (3M) + Explanation (3M))

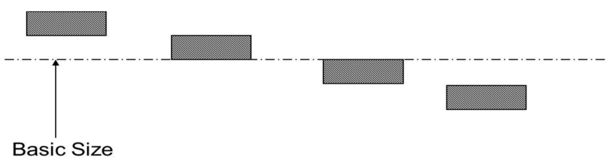
Ans:

i. Unilateral and Bilateral tolerances

Unilateral system

Unilateral system: The dimension of the part is allowed to vary only in one side of the basic size.

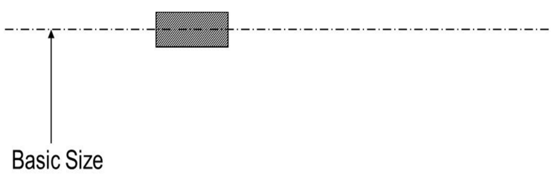
Eg:- $25^{+0.002\ +0.000}$



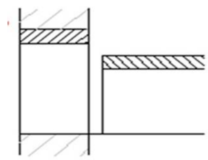
Bilateral system

The dimension of the part is allowed to vary on both sides of the basic size.

Eg:- $25^{\pm 0.0025}$

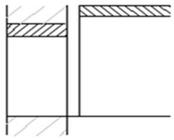


ii. Clearance and interference fits



Clearance fit: It is a fit that always enables a clearance between the hole and shaft in the coupling. The lower limit size of the hole is greater or at least equal to the upper limit size of the shaft.

Interference fit: It is a fit always ensuring some interference between the hole and shaft in the coupling. The upper limit size of the hole is smaller or at least equal to the lower limit size of the shaft.



iii. Tolerance and allowance

S.No	Tolerance	Allowance
1	Permissible variation in dimensions of a part.	Prescribed difference b/w two mating parts.
2	Difference of higher and lower limits of a part.	Difference b/w lower limit of a hole and higher limit of a shaft.
3	Provided since it is not possible to make part to its exact size.	Provided to get the required fit.
4	It is absolute value without sign.	It may be positive or negative.

b. Discuss in briefly, shaft and hole basis system of fits. Which is preferred and why?

S.No	**Characteristics**	**Hole Basis system**	**Shaft Basis system**
1	Definition	Size of a hole whose lower deviation is zero is taken as basic size	Size of a shaft whose upper deviation is zero is taken as basic size
2	principle	Limits on hole are kept constant and those of shaft are changed to get desired fit	Limits on shaft are kept constant and those of hole are changed to get desired fit
3	Suitability for Mass Production	Yes	No
4	Capital investment	Less	More
5	Ease of gauging	Easy	Complicated

Hole basis system is most preferred since it is easy to vary shaft sizes with a single lathe than varying the hole sizes. To vary the hole sizes, different sizes of drill bits are requires, which can increase the capital imvestment.

3. Solution:

Given:

Basic size = 50 mm, D = 38.73 mm (1M)

i = 1.561 microns (1M)

IT7 = 25microns = 0.025 mm,

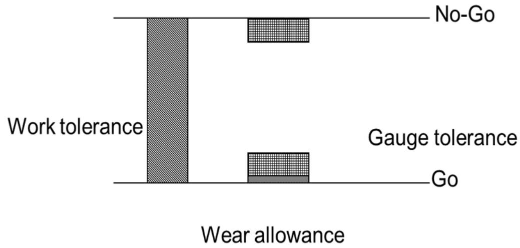
Hole-type: H7.

Gauge Tolerance = 10% of work tolerance = 0.00250 mm.

Wear Allowance = 10% of gauge tolerance = 0.000250 mm.

Limits of H hole: **(2M)**

LL of hole = Basic size = **50 mm = 'GO' Limit of Plug Gauge**
UL of hole = LL of hole + IT7
= 50 + 0.025
= **50.025 mm = 'NO-GO' Limit of Plug Gauge**



'GO' Gauge: **(1 M)**

LL of 'GO' gauge = 'GO' limit + Wear Allowance
= 50.0 **+** 0.00250 = **50.00250 mm**
UL of 'GO' gauge = LL of 'GO' gauge + Gauge Tolerance
= 50.00250 + 0.000250
= **50.00275 mm**

'NO-GO' Gauge: **(1 M)**

UL of 'NO-GO' gauge = 'NO-GO' limit = **50.025 mm**
LL of 'NO-GO' gauge = UL of 'NO-GO' gauge - Gauge Tolerance
= 50.025 – 0.00250
= **50.0225 mm**

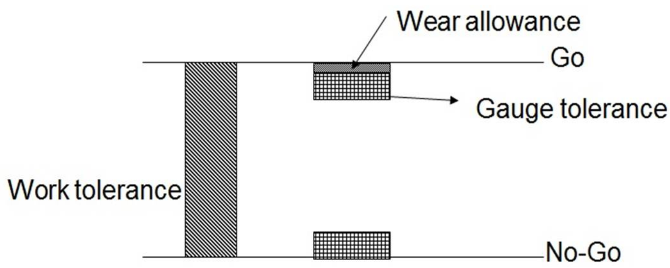
Limits of 'f' shaft: (2M)

F.D of 'e' shaft = $-16D^{0.44}$ = -79.96 microns = -80 microns = **-0.080 mm**

IT8 = 39.025 = 0.040 mm**,**

Gauge tolerance = 0.004 mm

Wear allowance = 0.0004 mm



UL of shaft = Basic size + F.D = 50 – 0.080 = **49.92 mm = GO Limit of the gauge**

LL of shaft = UL of shaft – Tolerance

= 49.92 – 0.04 = **49.88 mm = NO-GO Limit of the gauge**

Go Gauge: (2M)

UL of Go gauge = Go limit –Wear allowance

= 49.92 – 0.0004 = **49.9196 mm**

LL of Go gauge = UL of Go gauge – Gauge tolerance

= 49.9196 – 0.004 = **49.9156 mm**

NO-GO Gauge: (2M)

LL of NO-GO gauge = NO- GO limit = **49.88 mm**

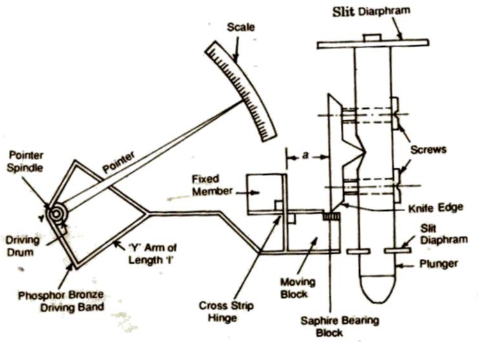
UL of NO-GO gauge = LL of NO-GO gauge + Gauge tolerance

= 49.88 + 0.004 = **49.884 mm**

4.

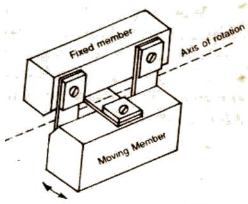
a. Describe any one of the mechanical comparators. How will you distinguish between mechanical and optical comparators? (Diagram (3M) + Explanation (3M))

Sigma comparator:



Sigma of comparator

- Mechanical comparator with magnification range of 300 to 5000.
- Consists of a plunger mounted on two flat steel strings providing frictionless movement of the plunger.
- Plunger carries a knife edge, which bears upon the face of the mounting block of the cross strip. Hinge.
- The cross strip hinge is formed by two flat steel springs arranged at right angles and is a very efficient pivot for smaller angular movements.
- Moving block carries a light metal Y-forked arm.
- A thin Phosphor bronze ribbon is fastened to the ends of the forked arm and warped around a drum, mounted on the spindle carrying pointer.



cross strip liver used in sigma comperator.

- The ratio of the effective length of the arm (L) and the distance (a) of the knife edge from the pivot gives the first stage magnification. And the ratio of the pointer length (l) and the radius of drum (r) gives second stage magnification.

$$Magnification = \left(\frac{L}{a} \times \frac{l}{r}\right)$$

- The magnification of the instrument can be varied by changing the distance (a) of Knife edge of tightening or slackening of the adjusting screws.

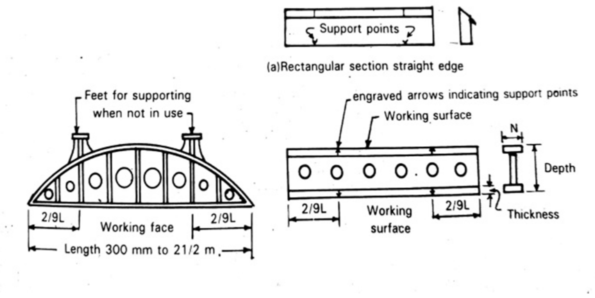
b. What is flatness? What are the various methods of checking flatness of surface? (Diagram (3M) + Explanation (3M))

Flatness: It is defined as minimum distance between two planes within which all the points on a surface lie. A surface along which all the points lie along single plane is called as perfectly flat surface. It is measured using straight edge.

- It is measured using straight edge.
- Used for checking straightness and flatness of the parts in conjunction with surface plates and spirit levels.
- IS:2200 covers C.I straight edges of two types of design:

1. Bow shaped straight edges from 300 to 800 mm length.
2. I- Section straight edge are made from close grained grey C.I.

- Widely used for testing machine tool slide ways.
- The bow shaped straight edges are heavily ribbed to prevent distortion.
- They are provided with feet upon which they can stand when not in use to prevent distortion under its own weight.
- The feet are provided at the point of minimum deflection.
- Steel or granite straight edges are available in rectangular cross-section in lengths up to 2000 mm and have beveled edge.



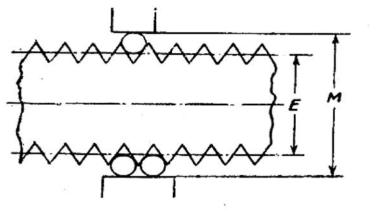
5.

a. What is meant by effective diameter of a screw thread? Explain with a neat sketch how the same can be measured using 3-wire method? (Diagram (3M) + Explanation (3M))

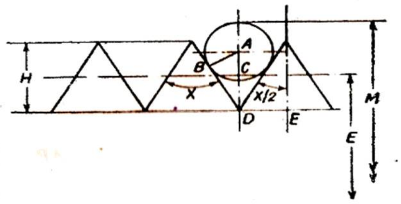
Effective diameter or pitch diameter: The diameter of a pitch cylinder, which intersects the flank of the threads in such a way as to make the width of threads and width of spaces between the threads are equal.

3-Wire Method:

- Accurate method for measuring effective diameter.
- This method ensures the alignment of micrometer anvil faced parallel to the thread axis.
- The wires may be held in hand or hung from a stand so as to ensure freedom to the wires to adjust them under micrometer pressure.



(a)



(b)

$$AD = AB\cos ec\frac{x}{2} = r.\cos ec\frac{x}{2}$$

$$H = DE\cot\frac{x}{2} = \frac{p}{2}.\cot\frac{x}{2}$$

$$CD = \frac{H}{2} = \frac{p}{4}.\cot\frac{x}{2}$$

$$AC = h = AD - CD$$

$$h = r.\cos ec\frac{x}{2} - \frac{p}{4}\cot\frac{x}{2}$$

- Effective diameter can be calculated as following:
- Reading on micrometer is M.

Then,

M=E+Q,

Where,

E= effective diameter

Q= constant depending upon the wire diameter and flank angle.

From the figure:

Distance over wires = M = E + 2h + 2r

$$= E + 2\left(r.\cos ec\frac{x}{2} - \frac{p}{4}.\cot\frac{x}{2} \right) + 2r$$

$$= E + 2r\left(1 + \cos ec\frac{x}{2} \right) - \frac{p}{2}.\cot\frac{x}{2}$$

$$M = E + d\left(1 + \cos ec\frac{x}{2} \right) - \frac{p}{2}.\cot\frac{x}{2}$$

b. Explain with a neat sketch how the same can be measured using 2-wire method?
(Diagram (3M) + Explanation (3M))

- The effective diameter of a screw thread may be ascertained by placing the two wires or rods of identical diameter between the flanks of the thread and measuring the distance outside of these wires.
- The effective diameter E is then calculated as

  E= T+P,

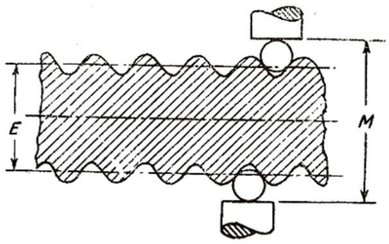
  where T=Dimension under wires = M-2*d*

  M= Dimension over wires,

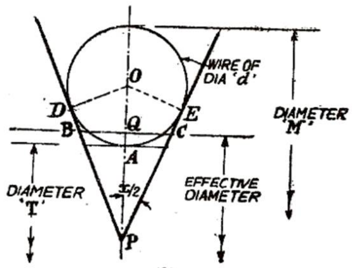
  d= diameter of each wire.

  P= It is a value which depends on the dia. of the wire and pitch of the thread.

- The dimension T can also be determined by placing wires over a standard cylinder of diameter greater than the diameter under the wires and noting the reading R_1 and taking the reading over the gauge, R_2 .
- Then, T=S-(R_1-R_2).
- If *p* is the pitch of the thread, then P=0.9605*p*-1.1657*d* (Whitworth thread), P= 0.866*p*-*d* (Metric thread)
- Actually P is a constant value that has to be added to T to give the effective diameter.
- The expression for the value of P in terms of *p, d* and *x* can be derived as follows:
- Since BC lies on the effective diameter line, BC= ½ Pitch=½.p



(*a*)



(*b*)

$$OP = \frac{d * \cos\ ec\left(x/2\right)}{2}$$

$$PA = \frac{d\left(\cos\ ec\left(x/2\right) - 1\right)}{2}$$

$$PQ = QC \cdot \cot\ x/2 = \frac{p}{4} \cdot \cot\ x/2$$

$$AQ = PQ - AP = \frac{p.\cot\ x/2}{4} - \frac{d\left(\cos\ ec\ x/2 - 1\right)}{2}$$

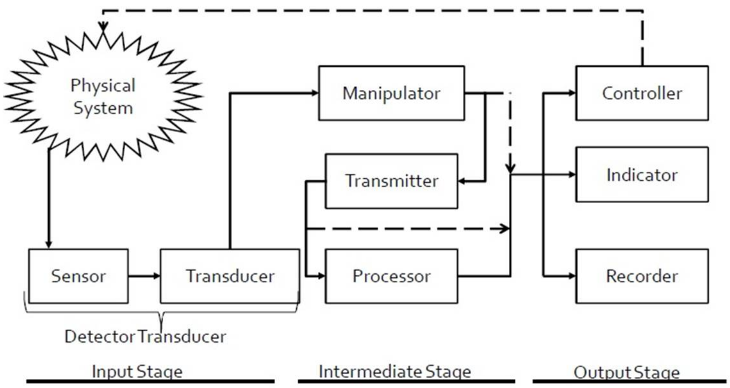
- AQ is half the value of P, P value= 2AQ,

$$P = \frac{p}{2}.\cot x/2 - d\left(\cos ec\frac{x}{2} - 1 \right)$$

- Two wire method can be carried out only on the diameter measuring machine because the alignment is not possible two wires and can be provided only by the floating carriage machine.

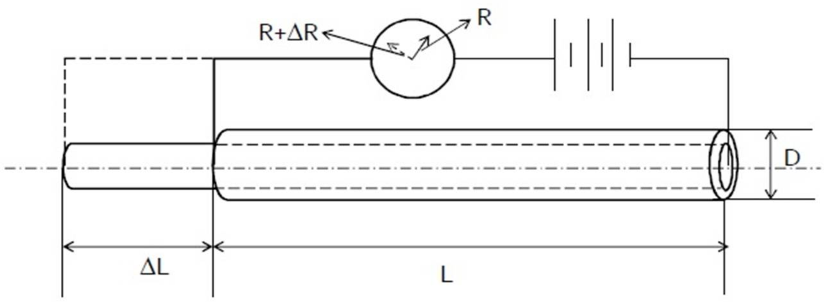
6.

a. With the help of a block diagram, show the stages of generalized measurement system. Also explain the functions of each stage. (Diagram (3M) + Explanation (3M))



- Sensor: An element that is sensitive to the measured variable. The sensing elements sense the condition, state or value of the process variable by extracting small part of energy from the measurand and then produce the output which reflects this condition, state or value of the measurand.
- Transducer : An element that converts the signal from one physical form into another without changing the information content of the signal. The signal after transduction is more suitable for purposes of measurement and control.
- Manipulator: An element that operates on the signal according to some mechanical rule without changing the physical nature of the variable.
  [Input] X Constant = Output
- Data Transmission Element: An element that transmits the signal from one location to another without changing its information content.
- Data Processing Element: An element that processes the data before it is displayed or finally recorded.
- Data Presentation Element: An element that provides a record or indication of the output from the data processing element.

b. Derive, from first principles, the relationship for gauge factor of a strain gauge.
(Diagram (3M) + Explanation (3M))



- Consider a conductor of length L, uniform cross-section A and uniform resistivity ρ.
- The resistance of the conductor is given by

$$R = \frac{\rho L}{A}$$

Taking logarithms ,

$$\log_e R = \log_e \rho + \log_e L - \log_e A$$

Upon differentiation ,

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \frac{dA}{A}$$

The area may be related to the square of the transverse dimension D.

$A = CD^2$ and $\frac{dA}{A} = \frac{2dD}{D}$

where C is constant

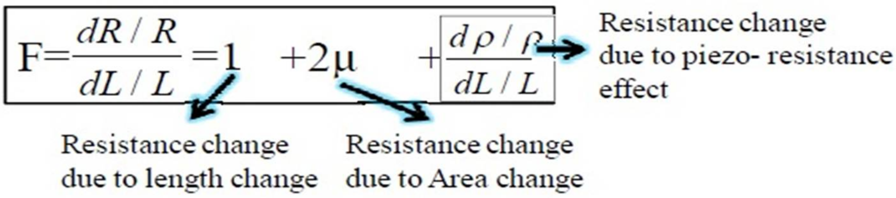
$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \frac{2dD}{D}$$

Dividing throughout by dL/L,

$$\frac{dR/R}{dL/L} = \frac{d\rho/\rho}{dL/L} + 1 - \frac{2dD/D}{dL/L}$$

$$\frac{dR/R}{dL/L} = \frac{d\rho/\rho}{dL/L} + 1 + 2\mu$$

$$F = \frac{dR/R}{dL/L} = 1 + 2\mu + \frac{d\rho/\rho}{dL/L}$$



F is called *Strain sensitivity factor* or *Gauge Factor*.

7.

a. Why rotameter is called constant head variable area flow meter? Explain the working rotameter with a neat sketch. (Diagram (3M) + Explanation (3M))

- Variable area flow meters are very simple yet versatile flow measurement devices for use on all types of liquids, gases and steam.

- They operate on the variable area principle, whereby a flowing fluid changes the position of a float, piston, or vane to open a larger area for the passage of the fluid.

- The position of the float, piston, or vane is used to give a direct visual indication of the flow rate.

- The rotameter is an industrial flow meter used to measure the flow rate of liquids and gases.

- Its operation is based on the variable area principle: fluid flow raises a float in a tapered tube, increasing the area for passage of the fluid.

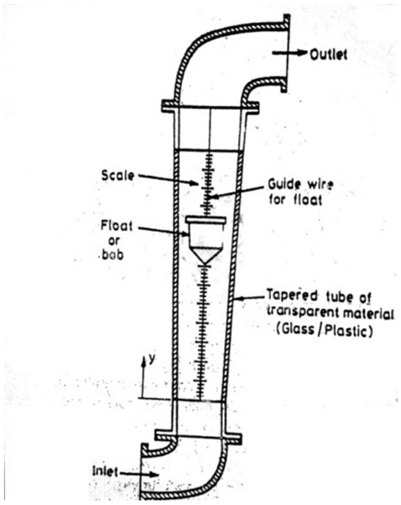
• The greater the flow, the higher the float is raised. The height of the float is directly proportional to the flow rate. With liquids, the float is raised by a combination of the buoyancy of the liquid and the velocity head of the fluid.

• With gases, buoyancy is negligible, and the float responds to the velocity head alone.

• The float moves up or down in the tube in proportion to the fluid flow rate and the annular area between the float and the tube wall.

• The float reaches a stable position in the tube when the upward force exerted by the flowing fluid equals the downward gravitational force exerted by the weight of the float.

• A change in flow rate upsets this balance of forces. The float then moves up or down, changing the annular area until it again reaches a position where the forces are in equilibrium.

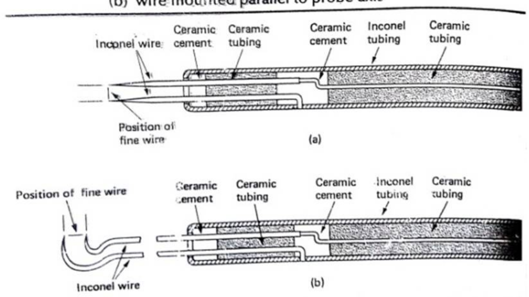


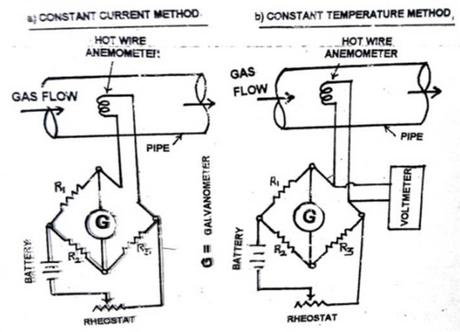
• To satisfy the force equation, the rotameter float assumes a distinct position for every constant flow rate.

• However, it is important to note that because the float position is gravity dependent, rotameters must be vertically oriented and mounted.

b. With a neat sketch, explain the working of hot-wire anemometer.
(Diagram (3M) + Explanation (3M))

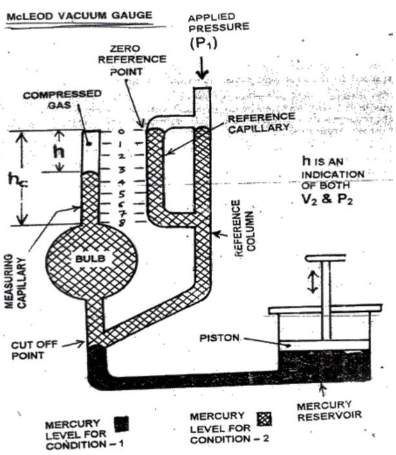
Figure Two forms of hot-wire anemometer probes:
(a) wire mounted normal to probe axis,
(b) wire mounted parallel to probe axis





8.

a. Explain with a neat sketch, the constructional features and basic working principle of McLeod gauge used for measuring low pressures. (Diagram (3M) + Explanation (3M))



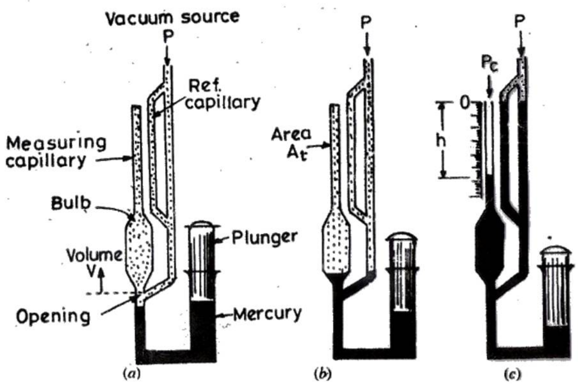


Fig. 9.40. McLeod Gauge.

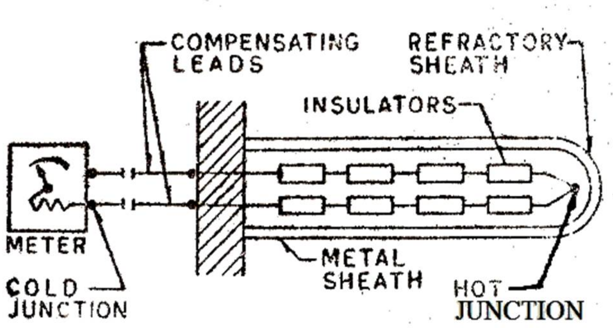
b. Classify temperature measuring instruments and explain the working of thermocouple for the measurement of temperature.

Classification of Temperature measuring instrument (2M)

Non-Electrical Methods	Electrical Methods
•Liquid, Vapour pressure and Gas Thermometers •Bimetal strip thermometers •Refractory cones, paints and crayons	•Electrical resistance pyrometers •Thermocouple pyrometers •Total radiation, photoelectric and optical pyrometers

Thermocouple: (Diagram (2M) + Explanation (2M))

Two dissimilar conductors electrically insulated except at the hot junction, where the conductors may either be soldered or welded together, or may be completely separated from each other.



Element of a thermo-electric pyromete

- A refractory and metal sheath to protect the thermocouple from injurious furnace gases and prevent it from mechanical damage.
- Compensating leads which allow the measuring instrument to be placed at considerable distance from the thermocouple without the necessity of using expensive thermocouple materials as extension leads.
- The cold or the reference junction is provided by the instrument used for measuring emf.

9.

a. Explain the construction and working of pneumatic load cell.
(Diagram (3M) + Explanation (3M))

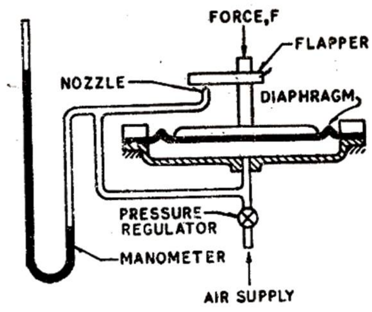


Fig. 13.9 Pneumatic load cell

b. Explain the principle of measuring shaft torques using rope brake dynamometer.

(Diagram (3M) + Explanation (3M))

The rope brake affords the following advantages :

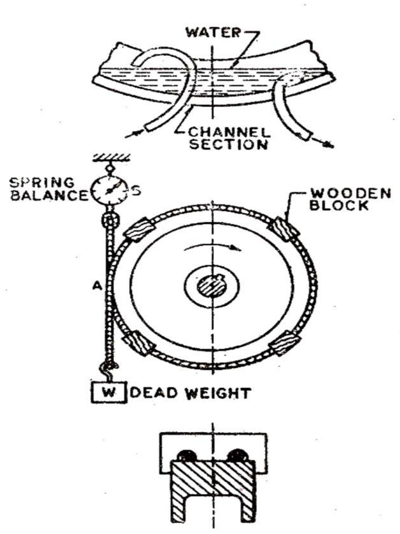
* generally much steadier in operation than the Prony brake
* easier to make
* suitable for wide range of powers
* requires no lubrication
* can be used for long trials with little danger of overheating and without requiring adjustment
* applying equation $\frac{T_1}{T_2} = e^{\mu\theta}$, the tension T_2 of the slack side of

$$R_{eff} = \frac{(D+d)}{2}$$

Braking Torque = $(W-S)R_{eff}$

If the engine turns N revolutions per minute, then

$$\text{Power} = \frac{2\pi N(W-S)R_{eff}}{4500}$$



Rope brake dynamometer

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