CBCS SCHEME

USN | | | | | | | | | | |

18ME36B/18MEB306

Third Semester B.E. Degree Examination, Jan./Feb. 2021
Mechanical Measurements and Metrology

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. What are the objectives of metrology? **(05 Marks)**

b. With a neat sketch explain the Imperial standard yard. **(10 Marks)**

c. A Calibrated metre and bar has an actual length of 1000.0006mm. It is to be used in the calibrate of two bars A and B each having a length of 500mm.
When compare with metre bar $L_A + L_B$ was found to be shortened by 0.0003 mm. In compare A with B, it was found that A was 0.0005 mm longer than B. Find the actual length of A and B. **(05 Marks)**

OR

2 a. Explain the wringing phenomena of the slip gauges. **(05 Marks)**

b. Build the dimension 83.3435mm from M87set. **(05 Marks)**

c. With a sketch explain the Autocollimator and how do you measure the straightness with this? **(10 Marks)**

Module-2

3 a. With a general sketch explain the limits, tolerance Fits, Allowances and Deviations. **(10 Marks)**

b. Explain the Hole basis and shaft basis systems for a fits. **(10 Marks)**

OR

4 a. List the functional requirements of a comparator. **(05 Marks)**

b. With a neat sketch explain the electrical comparator. **(10 Marks)**

c. With a sketch label the parts of Zeiss Ultra optimeter. **(05 Marks)**

Module-3

5 a. With a sketch, show the terminology of screw threads. **(05 Marks)**

b. How do you measure the major and minor diameter of an internal threads? **(10 Marks)**

c. Write a note on tool markers microscope. **(05 Marks)**

OR

6 a. Explain the Gear Tooth Thickness measurement using constant chord method. **(10 Marks)**

b. With a neat sketch explain the Gear Roll tester for composite error. **(10 Marks)**

Module-4

7 a. What are the significance of the measurement? **(05 Marks)**

b. Explain the stages in Generalized measurement system. **(10 Marks)**

c. List and brief the classification of errors. **(05 Marks)**

OR

8	a.	Explain the primary and secondary transducers.	(05 Marks)
	b.	What are the inherent problems of mechanical intermittent elements?	(05 Marks)
	c.	With a neat sketch explain the working of Cathode Ray Oscilloscope.	(10 Marks)

Module-5

9	a.	With a sketch explain the Prony Brake dynamometer.	(10 Marks)
	b.	Explain the working of a McLeod gauge with a neat sketch.	(10 Marks)

OR

10	a.	Explain the mounting of strain gauges.	(05 Marks)
	b.	Explain the methods of strain measurements.	(10 Marks)
	c.	What are the Laws of Thermocouple?	(05 Marks)

* * * * *

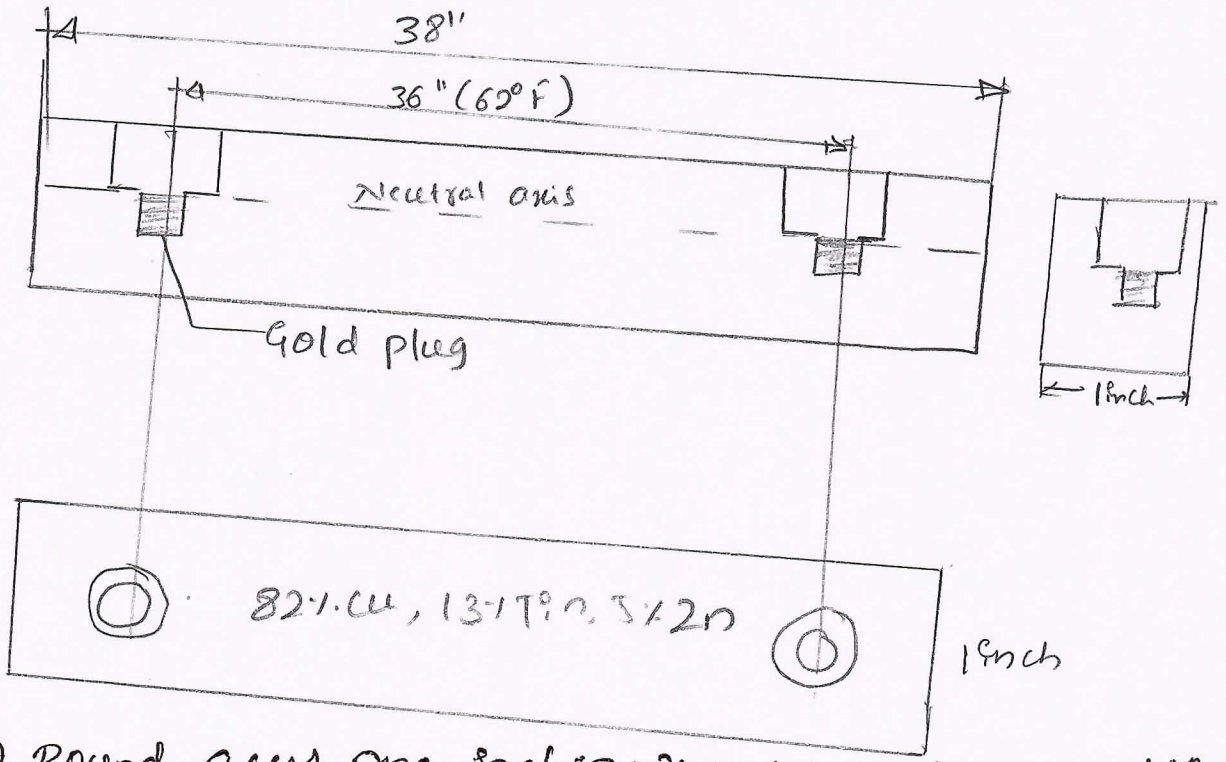
Scheme and solution.

Sub: Mechanical Measurement & Metrology 18ME36B/46

1.a. Objectives of Metrology.

- To provide the required accuracy at minimum cost
- To determine process capabilities.
- Through evaluation of newly developed products and ensure that components are with in the specified dimension.
- To determine process capabilities
- To reduce cost of inspection by efficient and effective utilization of available facility

b. Imperial standard yard

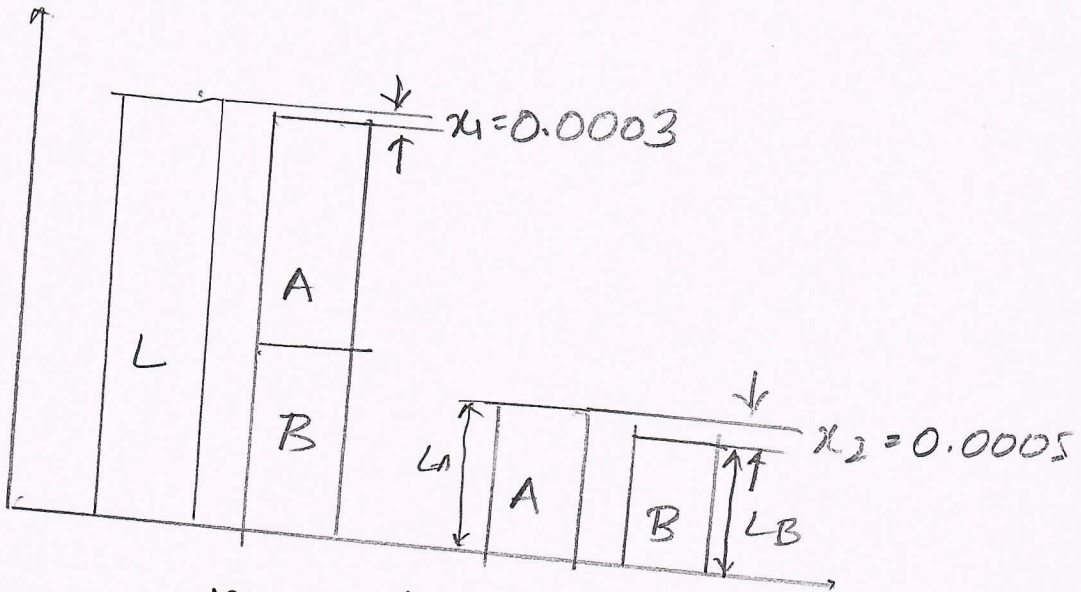


- A Round acess one inchaway from the two ends is cut at both sideends upto the Centre or neutral plane of the bar. - 4M.
- Further a small round acess of 1/10 inch in diameter is made below centre.
- Two gold plug 1/10 inch in diameter having engraving are inserted in to these holes so that the lines are neutral plane.
- Yard is defined as distance between the two central transverse lines of gold plug at 62°F.
- Purpose of keeping gold plug in line with the neutral axis is to ensure that neutral axis remain unaffected from bending.

Ver

1

C.



L = calibrated metre bar

1st Measurement

$$L = L_A + L_B + x_1$$

$$L - x_1 = L_A + L_B \quad \text{—— (1)}$$

2nd Measurement

$$L_A = L_B + x_2 \quad \text{—— (2)}$$

By eqn (1) & (2)

$$L - x_1 = L_B + x_2 + L_B$$

$$2L_B = L - x_1 - x_2$$

$$L_B = \frac{1000.0006 - 0.0003 - 0.0005}{2}$$

$$\therefore L_B = 499.9999 \text{ mm}$$

$$L_A = L_B + x_2 = 499.9999 + 0.0005$$

$$\therefore L_A = 500.0004 \text{ mm}$$

2b.

M-87 set — 5M

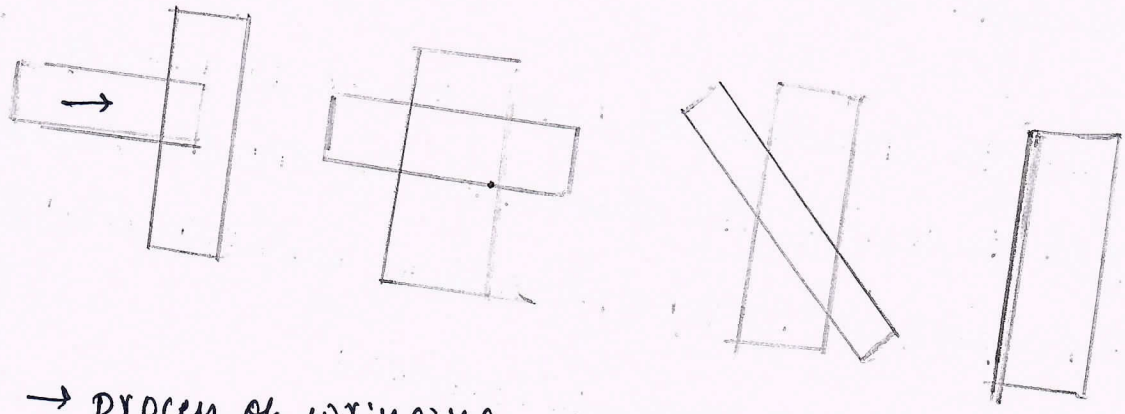
$$\begin{array}{r} 83.3435 \\ -\ 1.0005 \\ \hline 82.343 \\ -\ 1.003 \\ \hline 82.34 \\ -\ \ 1.34 \\ \hline 81.00 \\ -80.00 \\ \hline 1 \end{array}$$

$83.3435 = 1.0005 + 1.003 + 1.34 + 80 + 1$

1.0005	1.003	1.34	80	1

2a. Explain the wringing phenomena of slip gauges 05

Ans →



→ 1M

→ procen of wringing

4M

1. Wiping a clean guage block across an oiled pad.
2. Wiping any extra oil off the guge block using dry pad.
3. The block is then slid flat across the other block while applying moderate pressure until they form a cruciform
4. The phenomenon of wringing occurs due to molecular adhesion between liquid film.
5. Finally, the block is rotated until it is inline with the other block.

Limitations of sine bar

2M

- Value of error increases for angle measurement more than 45°
- difficult to operate with combination of slipguage
- Fixed length between the cylinders limit the application of sine bar.

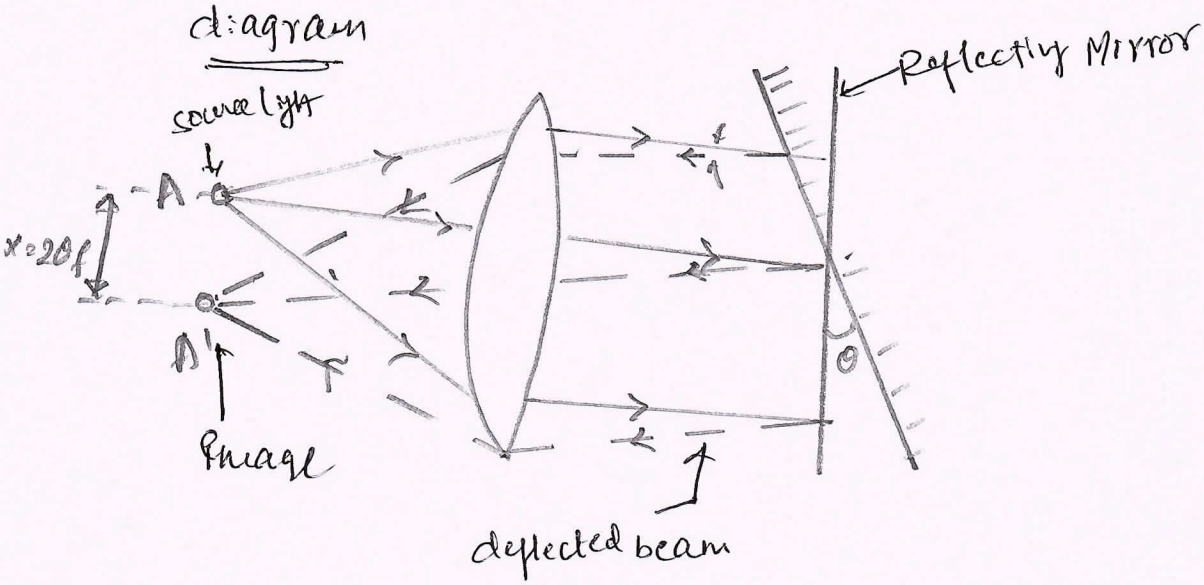
2C.

Principle of working of Autocollimator

(Total 7M)

- Basically auto collimator is telescope used for collimating other instrument.
- collimating lens used to convert light ray into paiallel beam of ligth.

diagram



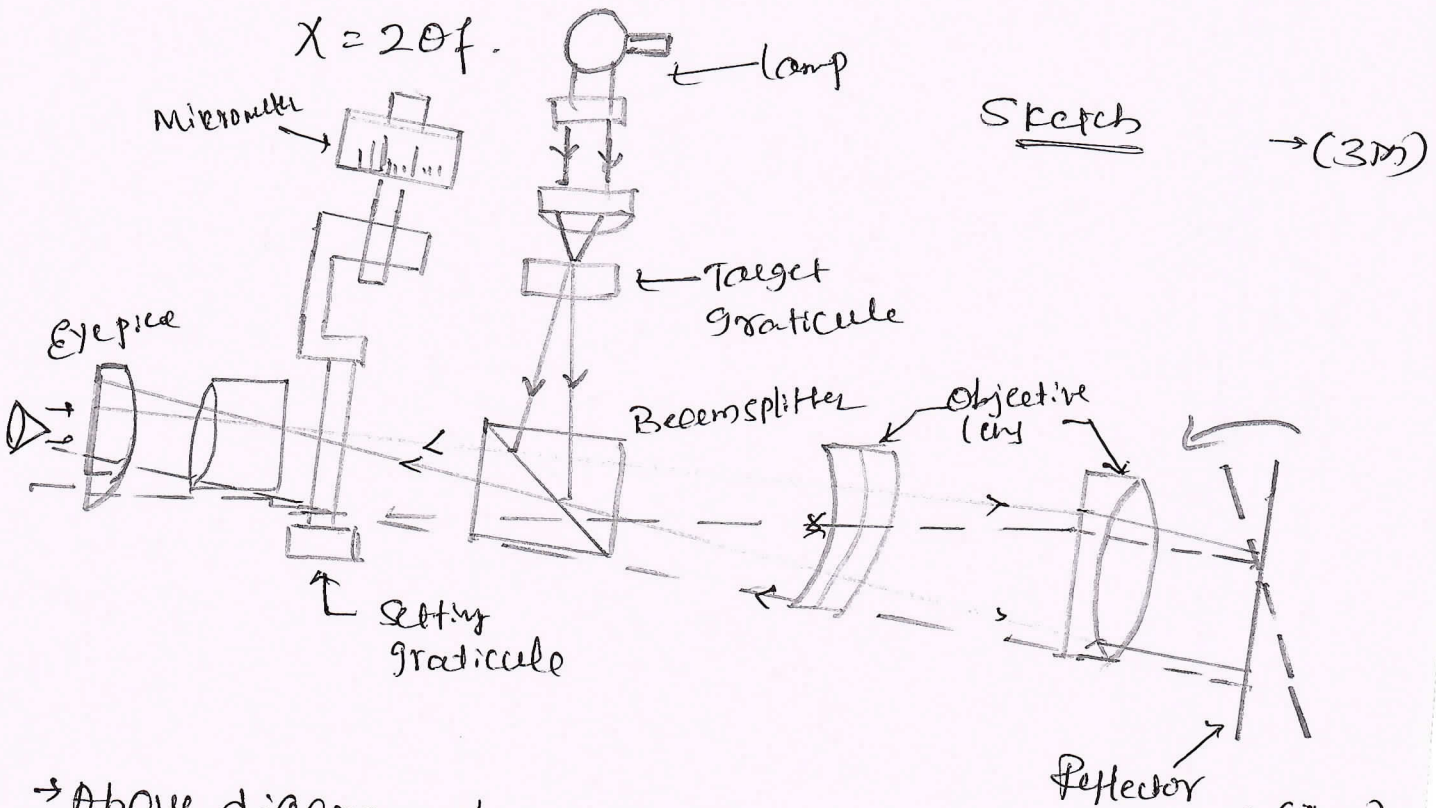
- A collimating lens is used to convert the light rays in to parallel beam of light
- let A be the point source of light placed at the principle focus of a collimating lens

2c.

The light rays when incident on collimating lens it travels parallel to the lens

- After striking the reflecting mirror, the rays are reflect-ed back along the same path & again concentrate at source point A.
- If the reflecting mirror is tilted an angle θ then the reflected ray from it will concentrate at same point A' & rays will deflected through angle 2θ.

$X = 2\theta f$.



Sketch → (3M)

→ Above diagram shows arrangement of autocollimator → (4M)
It consist of three main parts viz, micrometer, light unit & collimating lens

→ A target graticule situated at one side of instrument axes of right angle to main axes

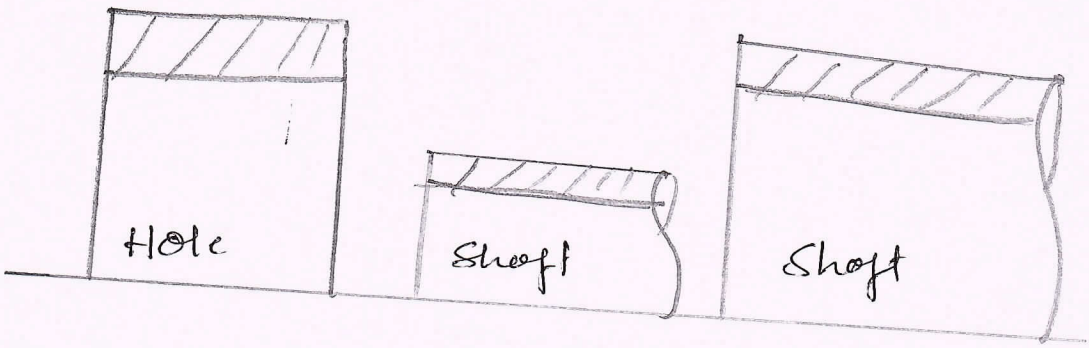
→ A 45° transparent beam splitter reflects the light from graticule towards the reflector

→ The rays are reflected back & get focussed in eye piece of Micrometer

3b. Total(7

Hole Basis system

→ (3M)

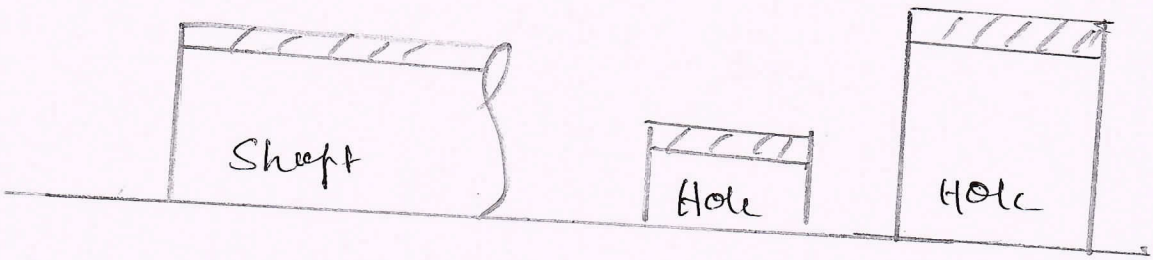


→ In this seystem hole is kept constant & shaft dimensions is get Velied in order to make different types of fits.

→ In this case, lower deviation of hole component is zero.

Shaft basis system

(3M)



→ In this system shaft is kept constant & Hole dimensions are Velied to get different types of fits

→ In this case upper deviation of shaft kept zero.

→ Shaft Basis system not preffered in mass production (1M) because, this system need large amount of storage space for different tools investment and required to produce holes of different sizes.

Next.

4a. Total (05M)

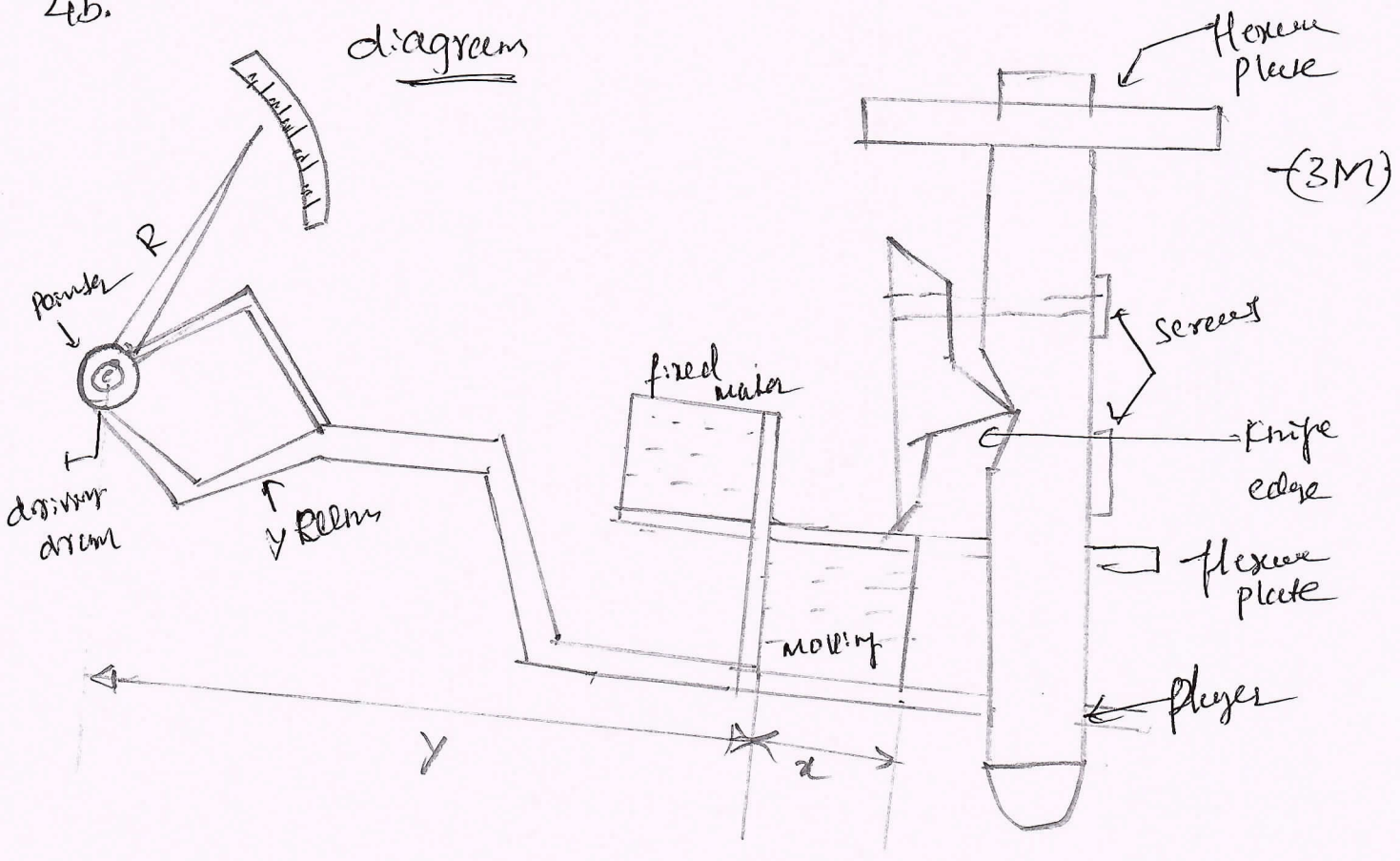
Comparator is a precision type of instrument which enables a comparision between the part being measured & length standard. (2M)

Need of comparator → (3M)

- In mass production it is important to manufacture component to close dimensional tolerances
- The use of vernier micrometer for accurate results require high degree of skill & need more time.
- Reduce require time once can use comparator.
- Reduce Rejections & Rework in production.

4b.

diagram



B.no

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4b cont/-

Working of sigma comparator (4M)

→ When the plunger moves in downward direction then the attached knife edge also moves in the same direction as that of plunger

→ As knife edge is connected to moving block, it applies the force on block & deflects it by angle θ.

→ Because of deflection, Y-arm changes it position by rotation drum of small radius r

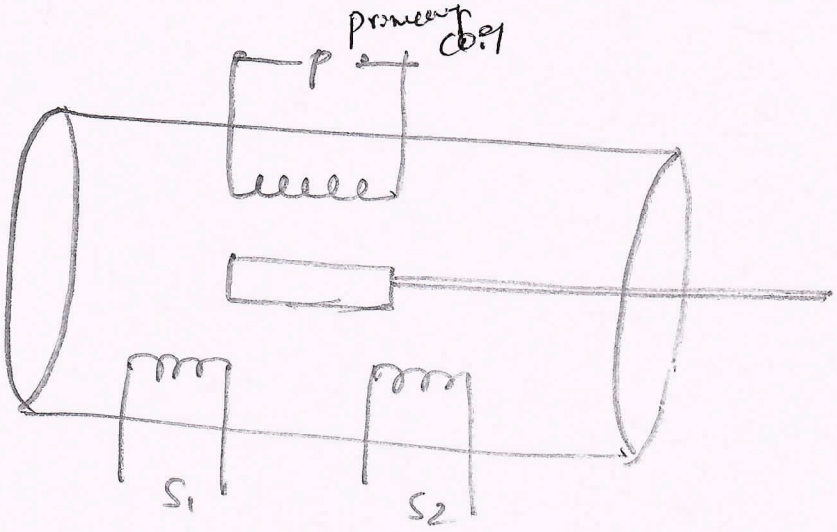
→ If L is length of Y-arm & distance from the hinge to edge is X, 1st stage magnification given by L/X

→ For 2nd stage if pointer radius R & drum radius r R/r

Total Magnification in comparator

$$M = L/X \times R/r$$

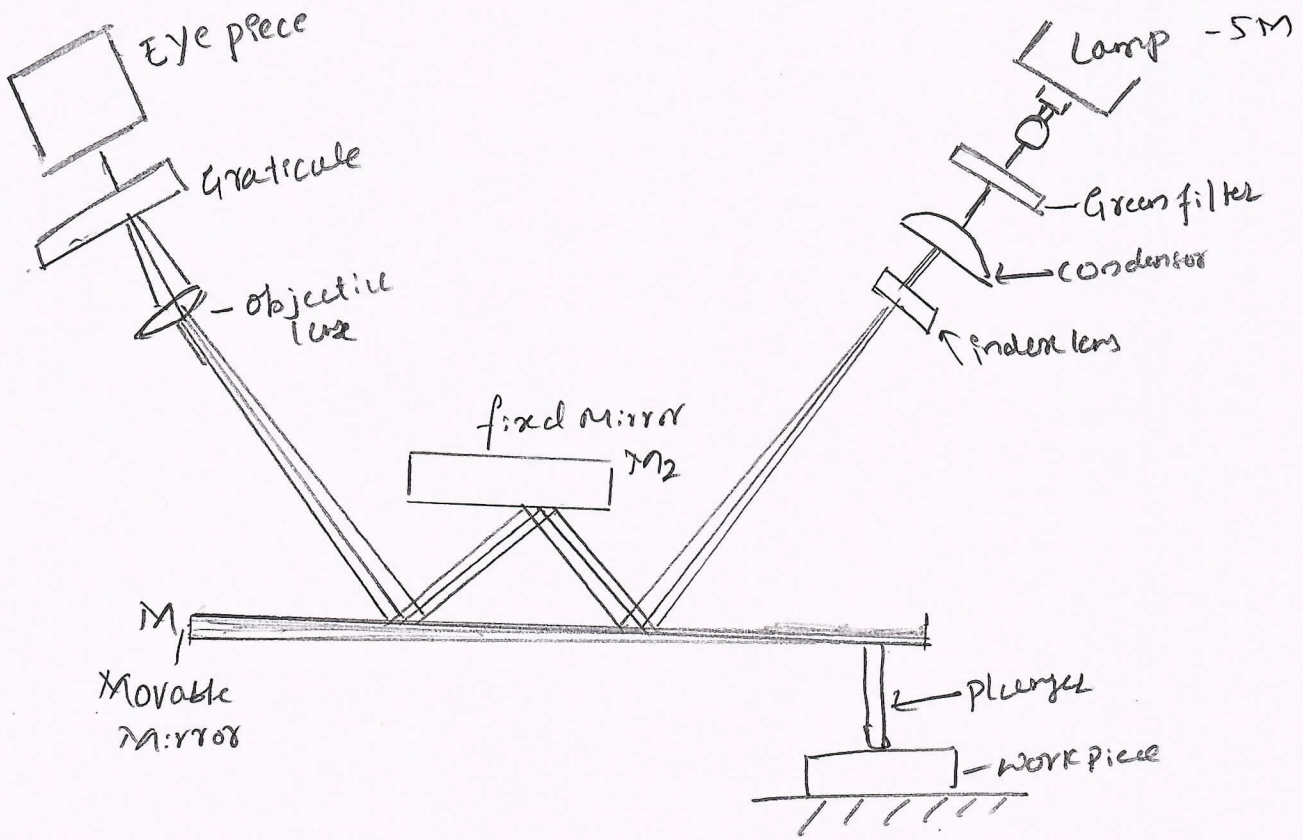
4c.



→ (3M)

S1, S2 → secondary coils

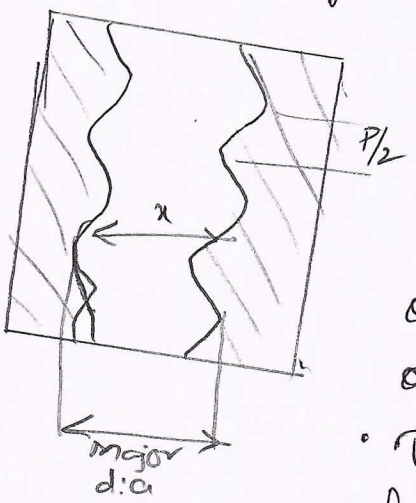
4. C. Zeiss-ultra optimeter



- The optical system of this instrument involves double reflection of light & thus gives higher degree of magnification.
- The green light from lamp passes through condensor which has an index mark project at 00 mirror M_1
- reflected to mirror M_2 again mirror M_1. the objective lens brings the reflected beam from the movable mirror to focus at a transperent graticule containing precise scale which is observed by eyepiece.

5.

b. Measurement of Major diameter of External threads.

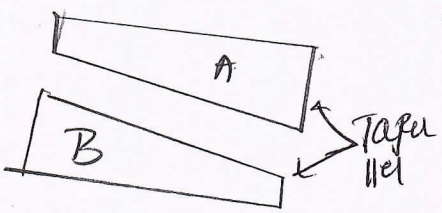


- Major diameter of external thread can be measured using a comparat
- It consist of a ballended styles of radius less than the root radius of thread to be measured.
- The stylus is attached to floatinghead which is kept in contact with the spindle of diameter.
- Comparator measure the distance x as shown in fig.
- The major dia (D) can be calculated by knowing value x from comparator as

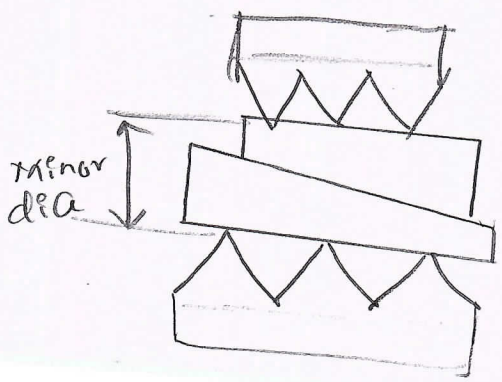
$$D = \sqrt{x^2 - (P/2)^2}$$

Measurement of minor dia:

1) Paper parallel



- Paper Ucl are used when the value of minor dia is less than 20mm
- Beside the thread taper Ucls are inserted adjacent until good contact is developed with the minor dia of thread as shown below diagram.



4c. Working of LVDT (4M)

- It consist of three symmetrical spaced coils wound insulated bobbin. A primary coil is wound on bobbin & two identical secondary coils are wound on bobbin on symmetry distance of primary

- An core is centrically set the middle pos'n of two secondary coils voltage is introduced in each secondary coil will be same & opposite zero.

→ when core moves on left or right side two voltages secondary coils S_1 & S_2 there is difference emf.

- the differential voltage appears across secondary in series which is further calibrated in terms of linear movement of core.

Module-3

(Total (6M)

5a.

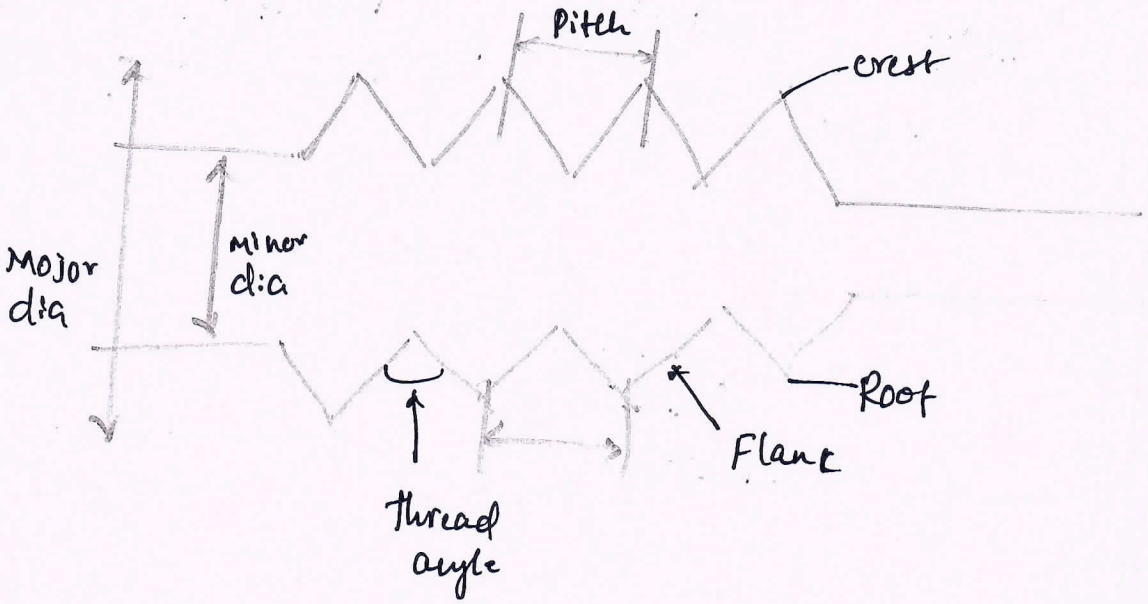
i) Pitch - It is distance measured parallel to the axis of screw from point on on thread to corresponding point on adjacent thread (2M)

ii) Lead: It is distance measured parallel axis screw which the nut will advance in one revolution of the screw. (2M)

iii) Crest of the thread: which joins the two sides of external screw thread. (2M)

5a. With Neat sketch, Explain Screw thread Gear terminology

Ans:-



- 2M

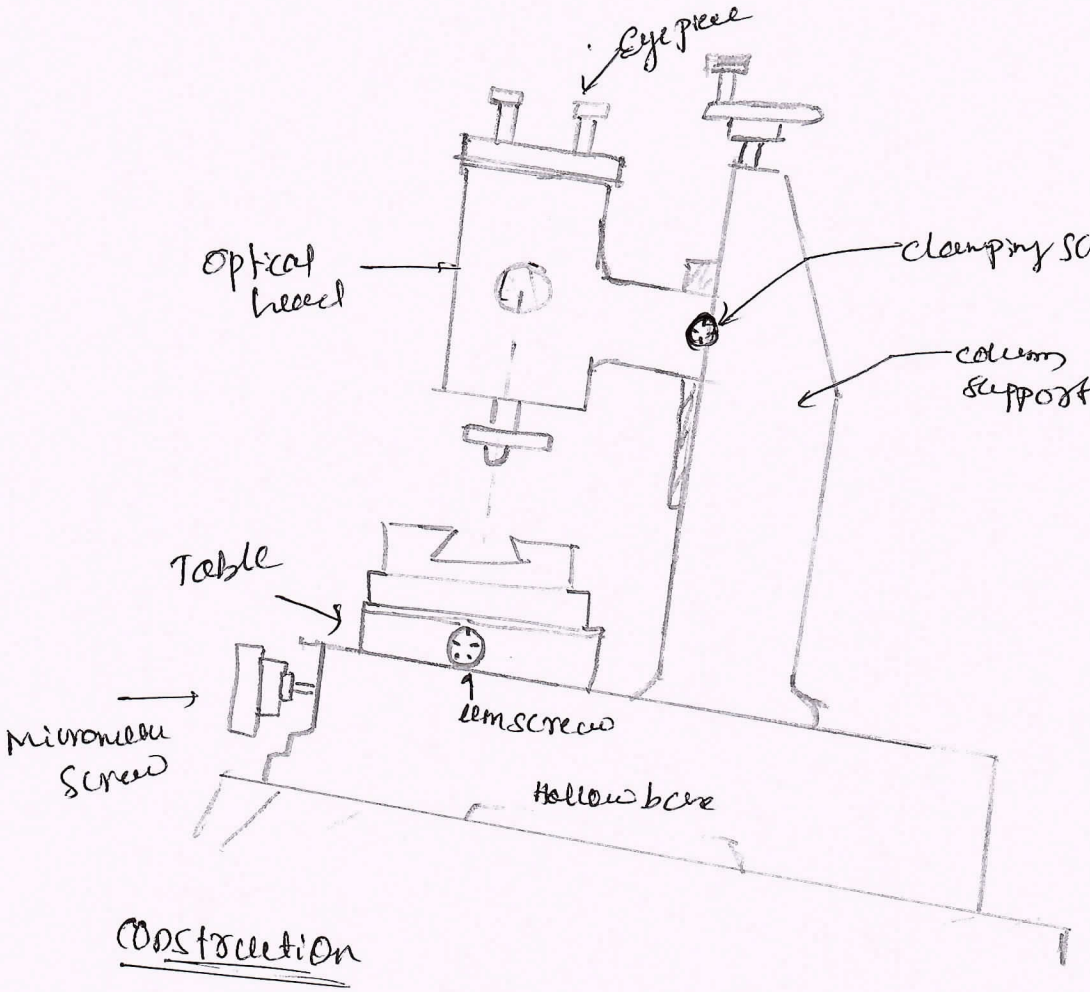
- Major diameter: It is diameter of major cylinder - 4M
- Minor diameter: It is diameter of minor cylinder Co-axial with screw touch Root of the external thread.
- Pitch → Distance bet^n consecutive crest or Root
- Crest → Crest is prominent part of thread which joins the two sides of External thread.
- → lead → It is angle made by the helix of thread with plane ⊥ar to axis of screw
- → Thread angle: It is angle bet^n flanks of thread measured in axial plane.

Ver.

5C

Tool makers microscope

Total (7M)



(3M)

Construction

(4M)

→ It consist of heavy hollow base for accommodating the illuminating unit. The table mounted on the base & it is equipped with micrometer screws to move it in mutually ⊥ directions in horizontal plane.

→ This table can be rotated through 360° & angular rotn can be read on fixed vernier scale

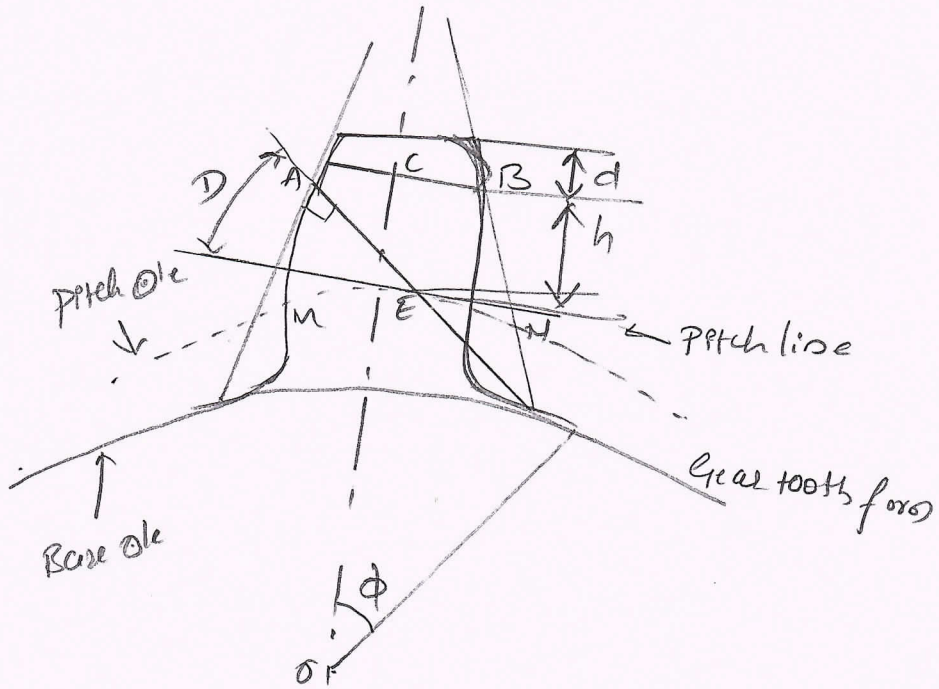
Working: Component is mounted on glass plate kept on table

- A light beam passes through transparent glass plate & shadow image of work piece passes through objective of optical head.
- By tilting measuring head, the dirn of light source can be tilted with respect to work piece
- Measurement purpose, the cross-lines marked on glass screen It rotated through 360° & angle measured.

pg.no-15

6a. Constant Chord Method

-10M

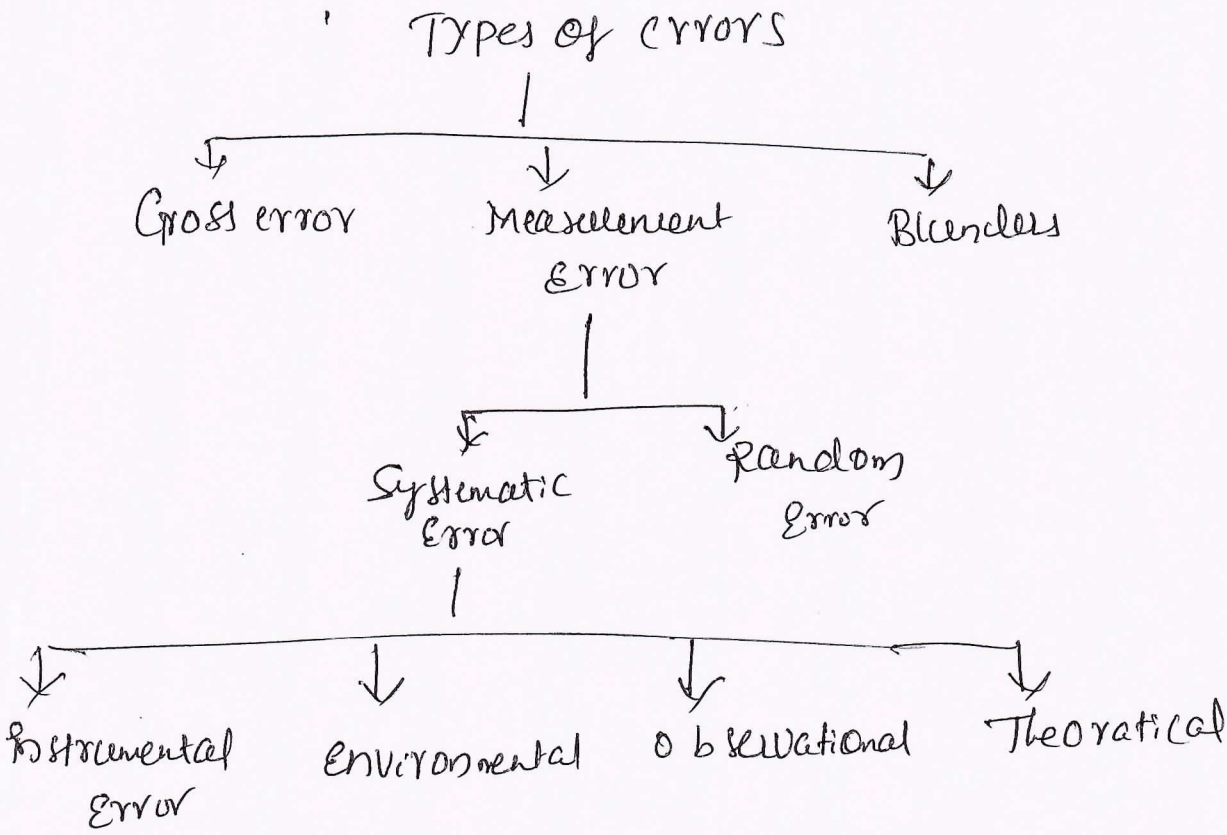


- In the previous method, it seen that both the chordal thickness & chordal addendum depends the NO. of teeth. hence measurement of large NO. of gears for set with different NO. of teeth involves more calculations & more time.
- Constant chord of gear is measured. where the tooth flanks touch the flanks of a base rack.
- The teeth of the Rack are straight & inclined to their centre line at pressure angle ϕ
- the contact always occurs at two fixed points A & B Hence length AB is known as constant chord.
- The value of AB & it's depth from the tip can be calculated mathematically & Manufactured using instrument.

7c. classification of errors.

+5

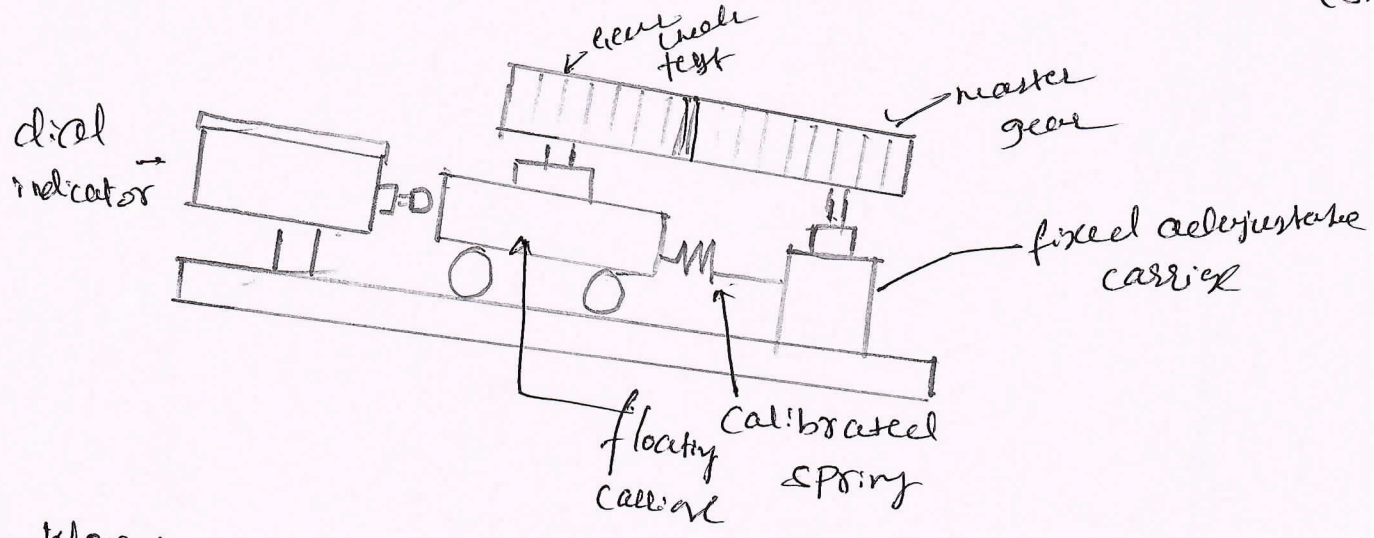
Three types of errors mainly: systematic error, random & blunders



Unit.

6b. Parkinson's Gear tester:

(3



Working

(5M)

→ Initially, by using guage block between the spindles set dial guage to read zero at correct center distance Also Adjust the spring pressure & set limit marks on dial guage

→ Mount the Master gear & gear under test on the respective spindles & observe the variation in the dial guage reading when gears are rotated.

→ If readings are within acceptable limit then gear is selected otherwise is rejected.

→ Electronic recorder is also fitted to instrument. It shows the variation in center distance from circular chart

→ Shows the gear tester testing spur gear.

→ accuracy of Parkison's gear tester is ±0.001 mm

Module-4

7a. (Total 6M) Each (1M)

i) Accuracy: The accuracy of instrument indicates the deviation of the reading from known input

ii) Precision: Measures reproducibility of instrument given fixed value of quantity or degree of accuracy for which instrument intended to perform

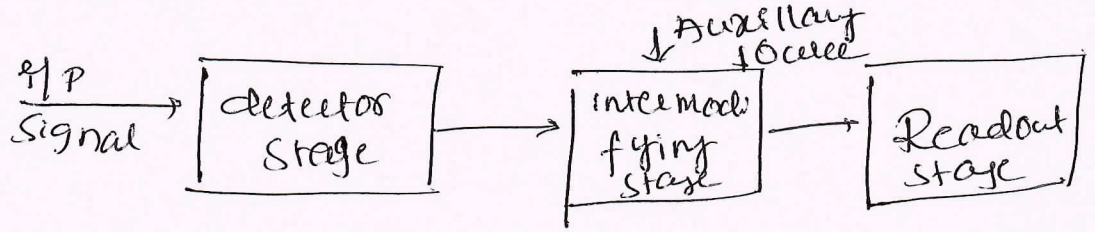
iii) loading effect: The incapability of system to faithfully measure the i/p signal is undistorted from is called loading effect

iv) Calibration: Ability to measure reliably for that procedures is adopted is called calibration.

v) Error: difference b/t measured value & true value

vi) Repeatability: is defined as ability of instrument to reproduce a group of measurement of same measured quantity under same conditions.

7b. Generalized measurement system (Total (8M))



(2M)

Contd-

7b. Stage 1: detector stage (4M)

The important function of the first stage is to detect or sense input signal.

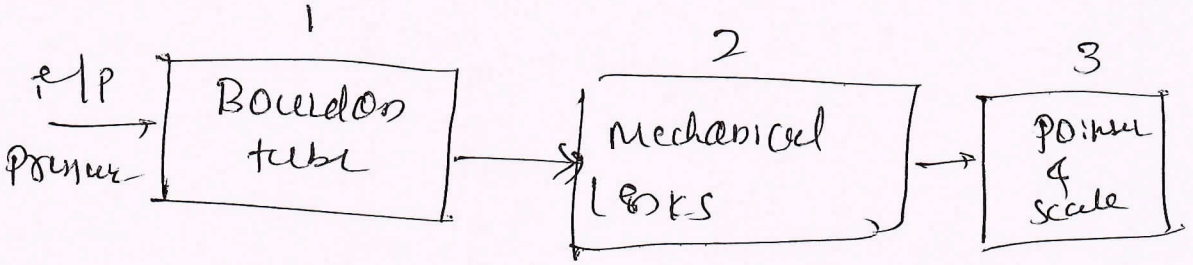
Stage 2: Intermodifying stage.

The purpose of second stage of generalized measurement system is to modify the transduced information so that it is acceptable to the last stage

Stage 3: Terminating stage

It provides the information required in a form which can be understood by human senses

Ex→ Bourdon tube



(2M)

Significance of measurement system (6M)

- Measurement provides fundamental for R&D
- development is final stage of design procedure involve measurement of various quantities to pertaining to operation.
- Measurement also fundmental element to any control process which measure discrepancy betn actual & desired.
- Many operations require measurement for proper peformance

Next.

8 a.

Primary and Secondary transducers.

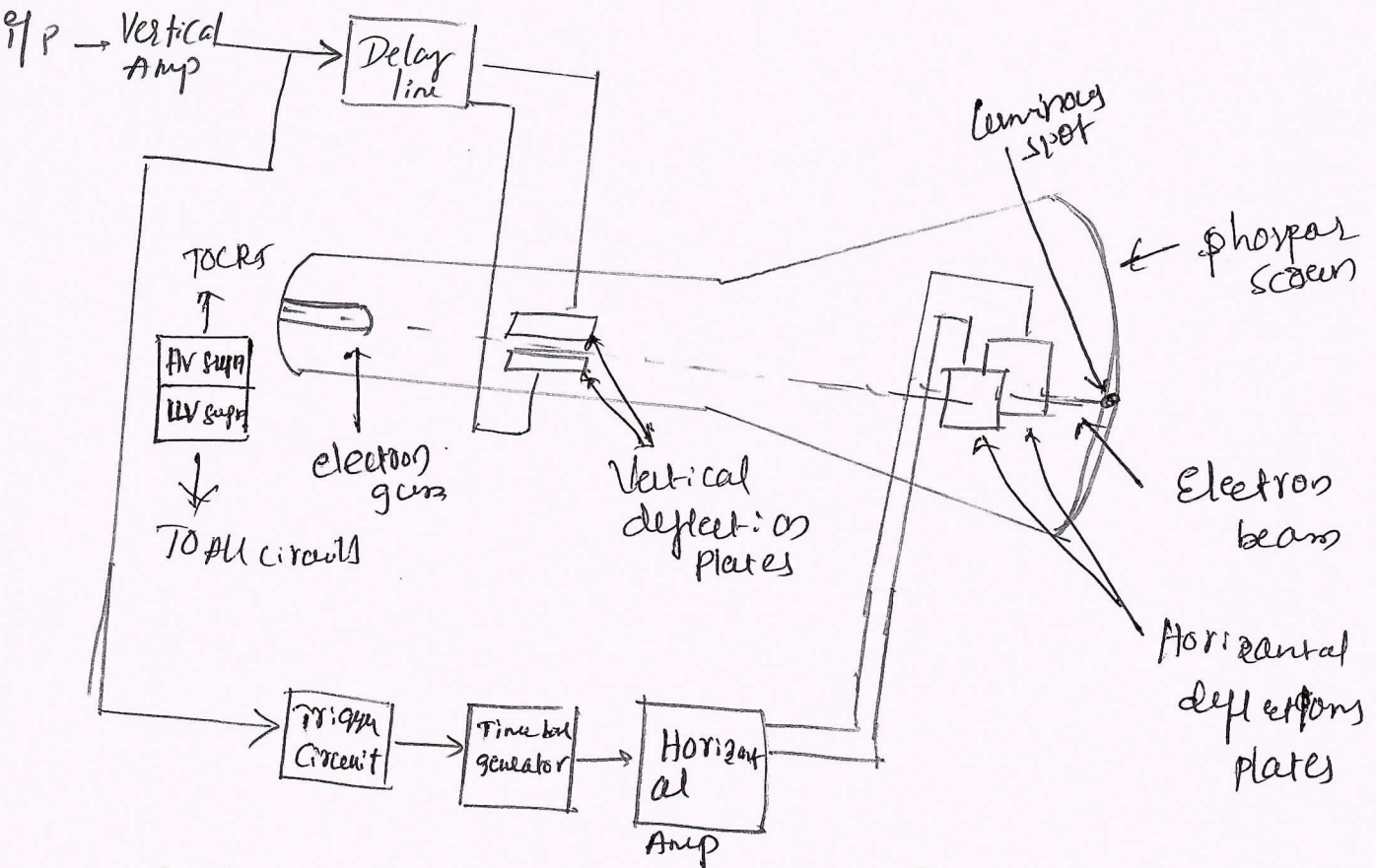
- Transducers contains the mechanical as well as electrical device. the mechanical device converts the physical quantity to be measured in to a mechanical signal. such mechanical device are called as primary transducers, because they deal with the physical quantity to be measured.
- The electrical device then convert this mechanical signal in to a corresponding electrical signal. such electrical device known as secondary transducer.

8

b. Inherent problems of Mechanical intermittent elements

- An ip signal is often converted to mechanical displacement by the first stage. Generally then it is fed to secondary transducers, which converts it into an Electrical form, which can easily deal intermediate stage devices.
- These mechanical elements existing design problems of considerable magnitude, particularly if dynamic inputs have to be handled.
- Some inherent problems such as
  1. Kinematic linearity
  2. Reflected frictional amplification
  3. Reflected inertial
  4. Tolerance problems
  5. Temperature problems.

8c.



Cathode-Ray oscilloscope (CRO)

- CRO is the most versitile readout device for mechanical measurements
- It is used for measurement & analysis of waveforms & other phenomenon in electrical & electronic circuit.
- CRO is instrument used for testing and observing constanty valing signal voltage
- CRO has fast processing and plots X-Y pattern at very fast rate.

Main parts of CRT

1) Glass envelope 2) electron gun assembly
3) deflection plate assembly 4) screen.

Glass envelope.

- It is conically shaped evacuated glass housing which maintains vacuum inside it & support various Electrodes
- The inner wall of CRT between neck & screen are coated with a conductive material known as aquadag

Electron gun Assembly: consist of an indirectly heated cathode, a control grid, a focusing anode & accelerating anode & it is used to produce a focused beam of electrons.

Deflection plate Assembly:

- It consist of two sets of deflecting plates within the beyond the accelerating anode & used for the deflection beam.
- One set is called as vertical deflection plates & the other called horizontal deflection plates.

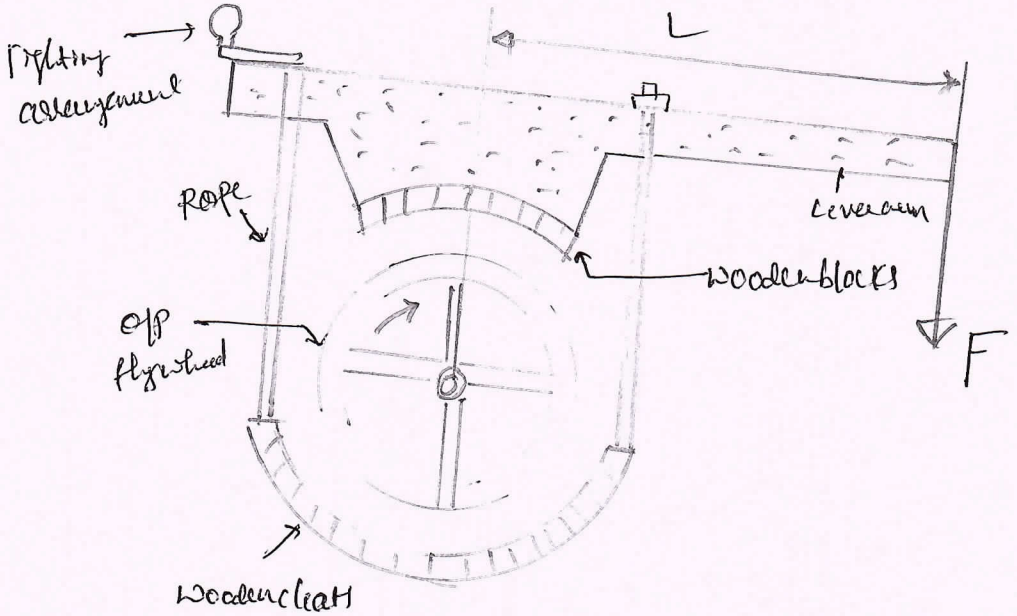
Screen:

- Screen is coated with some fluorescent material such as Zinc orthosilicate.
- Colour spot depends on nature of fluorescent material.

9 (a)

qa (ii)

prony brake dynamometer.



→ (3M)

- Two wooden blocks are mounted diametrically opposite on flywheel attached to the rotating shaft whose power is to be measured → (4M)
- One block carries a lever arm & an arrangement is provided to tighten the rope which is connected to the arm.
- The Rope is tightened as so to increase the frictional resistance between the blocks & the flywheel.
- The Torque exerted by prony brake is $T = F \cdot L$
- The power dissipated in the brake is calculated by following eqn.

$$P = \frac{2\pi NT}{60} = \frac{2\pi FLN}{60} \text{ watts}$$

$\therefore$ F = force in N, L = length of arm in m

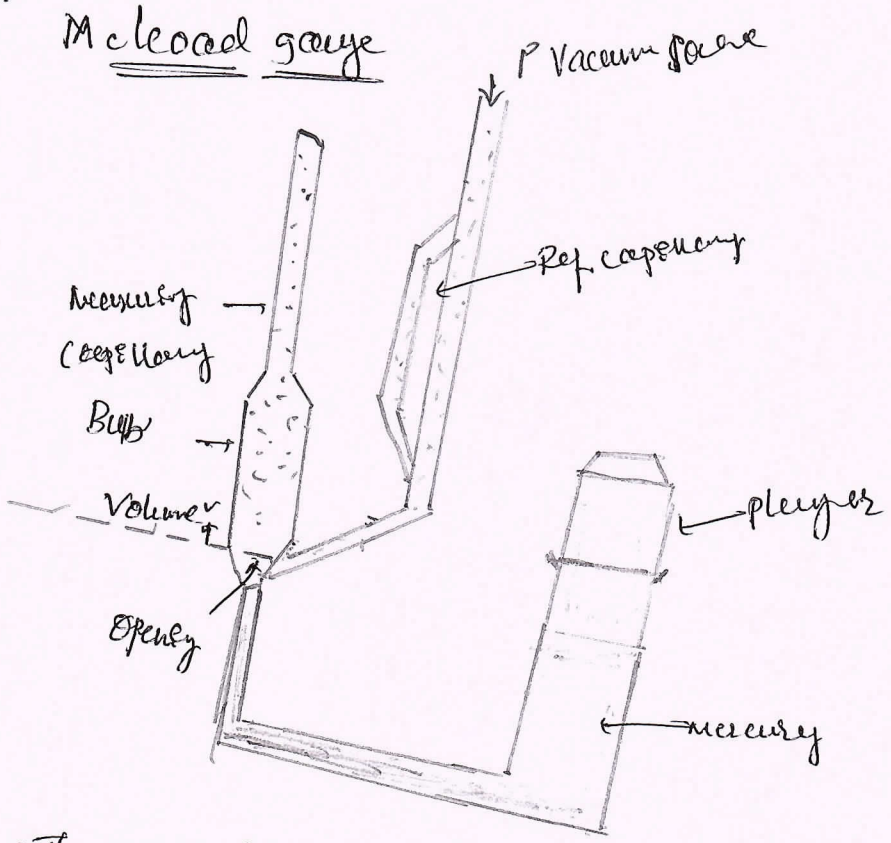
N is angular speed in rpm & P in watts

- The prony brake dynamometer is expensive, but it is difficult to adjust & maintain specific load.

9.c

Mcleod gauge

9.b



(4M)

- The operation of Mcleod gauge is based on boyle's law

$$P_1 = \frac{P_2 V_2}{V_1}$$

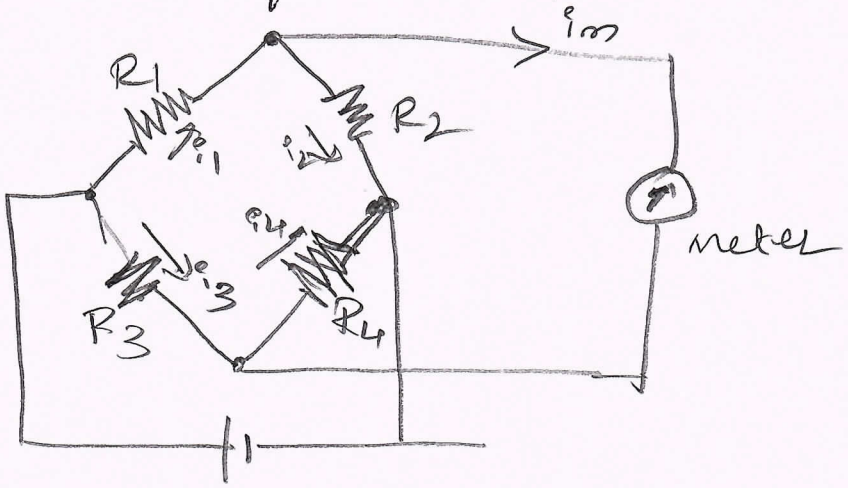
- when P_1 & P_2 are pressure at initial level & final conditions respectively & V_1 & V_2 are volumes.
- To start process of measurement, Plunger is withdrawn lowering the level of Mercury below the opening thereby admitting the gas at unknown pressure P.
- The bulb & measuring capillary are then at the same pressure as the Vacuum pressure. when plunger is pushed in, Mercury level goes up. sealing off gas sample of known volume V in the bulb & measuring capillary.
- Further motion of Plunger causes compression of the sample & motion of plunger is continued until the level of Mercury is at zero mark in ref. capillary
- a Mcleod gage is scientific instrument used to measure very low pressure. down to 10^{-6} Torr (mm)

10. b.

Methods of strain measurement

- Electrical resistance type of strain guages uses highly sensitive wheatstone bridge circuit for measurement of strain.
- It consistsof 4 resistance arms with source of energy & detector.
- the basic priciple of bridge may be applied in two different ways the Null Method & deflection method.
- Let us assume the Resistance have been adjusted so that bridge balanced.
- for bridge balance, the ratio of resistances of two adjacent arms must be equal to the ratio of resistances of the remaining two arms taken in the same sense.

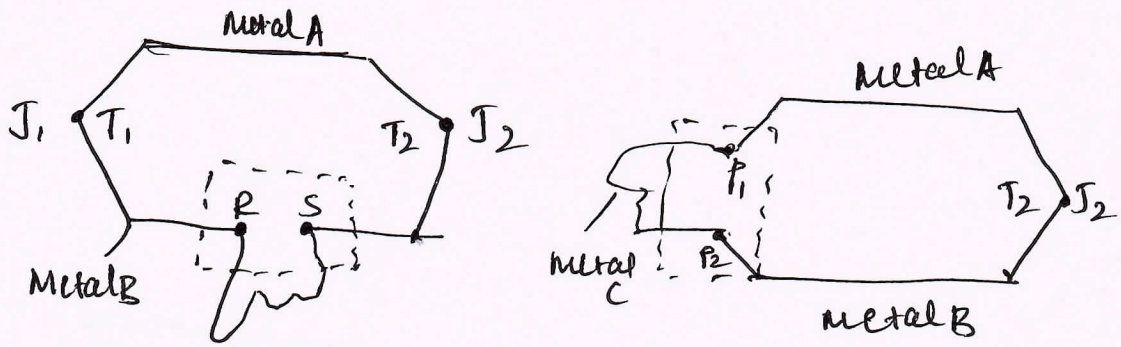
i.e $R_1/R_3 = R_2/R_4$



10 C. Thermocouple is type of temperature sensor, which is made by joining of two dissimilar metals at one end.

10 C. Laws of thermocouple

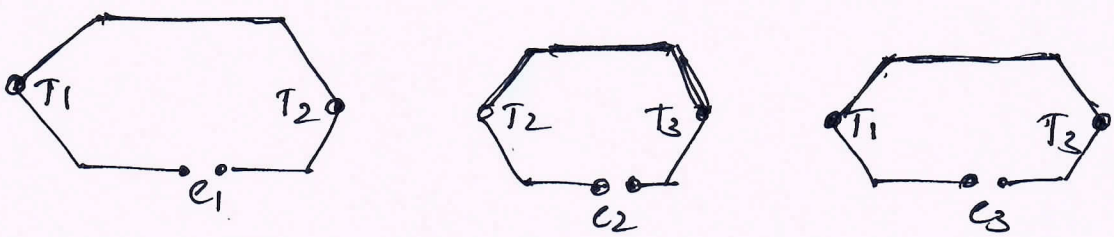
i) law of intermediate metals → (3M)



It states that insertion of an intermediate metal into thermocouple circuit will not effect emf, provided the two junctions introduced by third metal are at identical temperatures.

ii) Law of intermediate temperatures: It states that if a single thermocouple circuit develops an emf e_1 when junctions are T_1 & T_2 and an emf e_2, when it junctions are at Temperatures T_2 & T_3 Then same circuit will develop an emf $e_3 = e_1 + e_2$ when its junction are at temperature T_1 & T_3

→ 3M



law of intermediate states develops emf. when junction T_1 & T_2 & emf e_2 when temperature is E_2 & T_3, it given by $E_3 = e_1 + e_2$ when junction temperature T_1 & T_2.

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