METROLOGY AND MEASUREMENTS

LAB MANUAL

VEMU INSTITUTE OF TECHNOLOGY::P.KOTHAKOTA

Chittoor-Tirupati National Highway, P.Kothakota, Near Pakala, Chittoor (Dt.), AP - 517112
(Approved by AICTE New Delhi, Permanently Affiliated to JNTUA Ananthapuramu,
Accredited by NAAC, Recognized Under 2(F) &12(B) of UGC Act. and An ISO 9001:2015 Certified Institute)

Department of Mechanical Engineering

(20A03503P) METROLOGY AND MEASUREMENTS LAB

MANUAL

NAME :____

REGISTER NO. :____

SEMESTER :____

BRANCH :____

VISION OF THE DEPARTMENT

- To become a Centre of excellence in the field of Mechanical Engineering by producing graduates with technical knowledge, research, consultancy and entrepreneurial skills along with leadership qualities, ethics and lifelong learning to cater the needs of the society.

MISSION OF THE DEPARTMENT

- To impart quality education and training to nurture globally competitive mechanical engineers by effective teaching-learning practices and state-of-the art laboratories through eminent faculty.
- To establish linkages with industries and research organizations to bring excellence in problem solving skills, research and consultancy services.
- To empower the graduates with creative thinking, leadership qualities, lifelong learning skills, spirit of entrepreneurship, social and ethical values by offering value based education.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO_1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO_2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO_3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO_4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO_5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO_6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO_7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO_8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO_9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO_10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO_11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO_12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

A Graduate of the Mechanical Engineering Program will be able to:

S. No.	After graduation, the students will able to:
PSO_1	**Higher Education:** Apply the fundamental knowledge of mathematics, science, and Mechanical Engineering to pursue higher education in the areas of Design, Thermal and Manufacturing Engineering.
PSO_2	**Employment:** Get employed in core and allied industries through their proficiency in the program-specific domain knowledge, specialized computational package and programming or become an entrepreneur.

Programme Educational Objectives (PEOs)

PEO-1: To plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable.

PEO-2: To apply modern computational, analytical, simulation tools and techniques to address the challenges faced in mechanical and allied engineering industries.

PEO-3: To communicate effectively by using innovative tools, demonstrate leadership qualities, research & entrepreneurial skills, exhibit professionalism, ethical attitude, team spirit along with lifelong learning to achieve career and organizational goals.

Course Objectives:

- To experiment with measuring equipments used for linear and angular measurements.
- To find common types of errors in measurement equipment.
- To experiment with different types of sensors, transducers and strain gauges equipment.
- To make use of thermocouples for measurement of temperature.

Course Outcomes : At the end of course the students will be able to

CO 1	Apply different instruments to measure length, width, depth, bore diameters, internal and external tapers, tool angles, and surface roughness.
CO 2	Measure effective diameter of thread profile.
CO 3	Conduct different machine alignment tests.
CO 4	Measure temperature, displacement, and pressure.

CO – PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	
CO1	3				2	1	1		2			2	2	2	
CO2	3				2	1	1		2			2	2	2	
CO3	3				2	1	1		2			2	2	2	
CO4	3				2	1	1		2			2	2	2	

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B.Tech (ME)– III-I Sem | **L T P C** 0 0 3 1.5

(20A03503P) METROLOGY AND MEASUREMENTS LAB

List of Experiments

Section A:

1. Measurement of bores by internal micrometers and dial bore indicators.
2. Use of gear teeth Vernier callipers and checking the chordal addendum and chordal height of spur gear.
3. Alignment test on the lathe and milling machine using dial indicators
4. Study of Tool makers microscope and its application
5. Angle and taper measurements by Bevel protractor, Sine bar spirit level etc.
6. Thread measurement by Two wire/Three wire method.
7. Surface roughness measurement by Talysurf instrument.
8. Use of straight edge and sprit level in finding the flatness of surface plate.

Section B:

1. Calibration of Pressure Gauges
2. Study and calibration of Mcleod gauge for low pressure.
3. Calibration of transducer or thermocouple for temperature measurement.
4. Calibration of LVDT transducer for displacement measurement.
5. Calibration of capacitive transducer for angular measurement.
6. Calibration of photo and magnetic speed pickups for the measurement of speed.
7. Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.

Virtual Lab:

1. To use Vernier Callipers for the measurement of dimensions of given object.

https://amrita.olabs.edu.in/?sub=1&brch=5&sim=16&cnt=4

2. To use Micrometer Screw Gauge for the measurement of dimensions (Length, Thickness, Diameter) of given object.

https://amrita.olabs.edu.in/?sub=1&brch=5&sim=156&cnt=4

3. To calculate Young's modulus of elasticity of steel wire by Vernier method
4. https://amrita.olabs.edu.in/?sub=1&brch=5&sim=155&cnt=4

List of Experiments (College)

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2. Study and calibration of McLeod gauge for low pressure.
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4. Calibration of LVDT transducer for displacement measurement.
5. Calibration of capacitive transducer for angular measurement.
6. Calibration of photo and magnetic speed pickups for the measurement of speed.
7. Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.

SECTION B ADDITIONAL EXPERIMENT

1. Study of water flow rate using Rotometer

SCHEME OF EVALUATION TABLE

S.No	Experiment Name	Date	Marks Awarded				Total 30M
			Record (10M)	Observation (10M)	VivaVoce (5M)	Attendance (5M)	
1	**SECTION A** Measurement of bores by internal micrometers and dial bore indicators.						
2	Use of gear teeth Vernier callipers and checking the chordal addendum and chordal height of spur gear.						
3	Alignment test on the lathe and milling machine using dial indicators						
4	Study of Tool maker's microscope and its application						
5	Angle and taper measurements by Bevel protractor, Sine bar spirit level etc.						
6	Thread measurement by Two wire/Three wire method.						
7	Surface roughness measurement by Talysurf instrument.						
8	Use of straight edge and sprit level in finding the flatness of surface plate.						
1	**SECTION B** Calibration of Pressure Gauges						
	Study and calibration of McLeod gauge for low pressure.						

2	Calibration of transducer or thermocouple for temperature measurement.						
3	Calibration of LVDT transducer for displacement measurement.						
4	Calibration of capacitive transducer for angular measurement.						
5	Calibration of photo and magnetic speed pickups for the measurement of speed.						
6	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.						
1	**Sec B (Additional Experiment)** Study of water flow rate using Rotometer						

MEASUREMENTS OF BORES BY INTERNAL MICROMETERS AND DIAL BORE INDICATORS

EXP. NO: 1 **Date:**

AIM: To measure the length, height, inside and outside diameter by using Vernier Calipers, Dial Vernier, Micrometer & Digital Vernier.

APPARATUS:

Vernier calipers, Dial Vernier, Outside Micrometer, Depth Micrometer and Digital Vernier.

PRINCIPLE:

A) VERNIER CALIPER:

Caliper is an Instrument used for measuring distance between or over surfaces or for comparing dimensions of work pieces with graduated rules. It works on the principle of Vernier Scale which is some fixed units of length (Ex: 49mm) divided into 1 less or 1 more parts of the unit (Ex: 49mm are divided into 50 parts). The exact measurement with up to 0.02mm accuracy can be determined by the coinciding line between Main Scale and Vernier Scale.

Least count of Vernier:

Least count is the difference between the value of main scale division and Vernier scale division.

Least count = Value of smallest division on the main scale – value of smallest division on the Vernier scale. =……………………mm (Or)

Least count = Value of minimum division on the main scale / number of divisions on the Vernier scale =…………………...mm

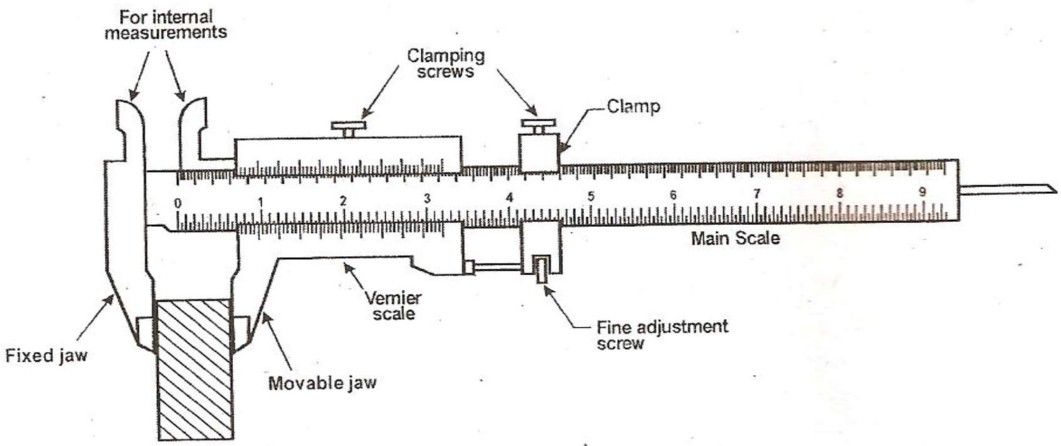


Fig. Vernier calipers

B) MICROMETER:

Micrometer is one of the most common and most popular forms of measuring instrument for precise measurement with 0.01mm accuracy. It works on the principle of screw and nut. We know that when a screw is rotated through one revolution it advances by one pitch distance i.e. one rotation of screw corresponding to a linear movement of a distance equal to pitch of the screw thread.

If the circumference of the screw is divided into number of equal parts say n its rotation through one division will cause the screw to advance through (pitch/n) length.

Least Count of Micrometer:

Least count is the minimum distance which can be measurement accurately by the instrument. The micrometer has a screw of 0.5mm pitch, with a thimble graduated in 50 divisions to provide a direct reading of pitch/n.

Pitch / n =   mm

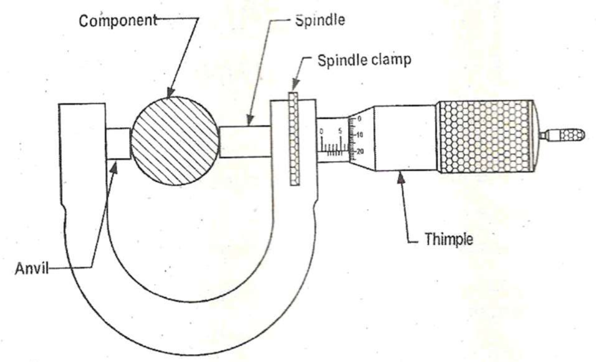


Fig . Outside Micrometer

<u>FORMULAE USED:</u>

Total Reading = M.S.R + L.C X V.C

Where:

M.S.R – Main Scale Reading, L.C – Least Count, V.C – Vernier Coincidence

<u>PROCEDURE:</u>

A) VERNIER CALIPER:

1. Close the two Jaws of the Vernier and check the zero error. In this position, the zero of Vernier scale should exactly match with zero of the main scale.

2. Hold the job between the jaws (The internal dimensions or internal diameter may be taken by using upper measuring jaws).
3. Note the number of millimeters and half millimeters on the scale that are coincident with zero on the vernier scale.
4. Find the graduation on the scale that coincides with a graduation on the main scale. Multiply this figure with least count to give the reading in millimeters. Obtain the total reading by adding the main scale reading to the vernier scale reading.
   i.e., Total reading= Main scale reading (M.S)+Least count (L.C)×Vernier scale reading (V.S)
5. Repeat this procedure three to four times and then calculate the average value.

B) MICROMETER:

1. Check the zero reading.
2. Place the job part to be measured in between the measuring faces of the anvil and spindle.
3. Advance the spindle by rotating the ratchet until it begins to slip and clicks are heard. This indicates that there is no further movement of the spindle.
4. Note the readings both on barrel scale and on the circular scale of the thimble.
   Total reading=M.S i.e., reading uncovered on the barrel +L.C × Circular scale reading (C.S) i.e., no. of divisions on circular scale which coincide with horizontal line on barrel.
5. Repeat the procedure three to four times and calculate the average values.

OBSERVATIONS:

S.NO	TYPE OF INSTRUMENT	LEAST COUNT (L.C)mm	MEASUREMENT/ SPECIMEN	TOTAL READING (mm)				AVERAGE READING (mm)
				TRAIL	M.S.R (mm)	V.S.R (mm)	TOTAL READING (mm)	
1.				I				
				II				
				III				
2.				I				
				II				
				III				
3.				I				
				II				
				III				
4.				I				
				II				
				III				
5.				I				
				II				
				III				
6.				I				
				II				
				III				
7.				I				
				II				

				III				
8.				I				
				II				
				III				
9.				I				
				II				
				III				
10.				I				
				II				
				III				

PRECAUTIONS:

A) VERNIER CALIPER:

1. Before starting the experiment, check the zero error of the vernier.
2. With Vernier Calipers, always use the stationary caliper jaw on the reference point and obtain the measured point by advancing or withdrawing the sliding jaw.
3. Grip the vernier calipers near or opposite the jaws; one hand for stationary jaw and the other hand generally supporting the sliding jaws.
4. Before reading the vernier try caliper again for feel and location.
5. While measuring an outside diameter, be sure that the caliper bar and the plane of caliper jaws are truly perpendicular to work piece's longitudinal centre line.
6. Vernier caliper must be kept wiped free form grit, chips and oil.

B) MICROMETER:

1. Before starting the experiment check the zero error of micrometers.
2. Micrometer should be cleaned of any dust and spindle should move freely.
3. The part whose dimension is to be measured must be held in left hand and the micrometer in right hand.

4. While measuring dimensions of circular a parts, the micrometer must be moved carefully over representative arc so as to note maximum dimension only.
5. The micrometers are available in various sizes and ranges, and the corresponding micrometer should be chosen depending upon the dimensions.

RESULTS:

1. The average values of dimensions of specimen ________using Vernier Calipers:
   Length: ________mm; Height: ________ mm ;Diameter _________mm
2. The average values of dimensions of specimen ________using Dial Vernier:
   Length: ___________mm; Height: ______________ mm; Diameter _________mm
3. The average values of dimensions of specimen ______________using Micrometer:
   Length: ____________mm; Height: ____________ mm; Diameter _________mm.
4. The average values of dimensions of specimen ________using Digital Vernier
   Length: ____________mm; Height: ______________ mm; Diameter _________mm

USE OF GEAR TEETH VERNIER CALIPERS AND CHECKING THE CHORDAL ADDENDUM AND CHORDAL HEIGHT OF THE SPUR GEAR

EXP. NO: 2 **Date:**

AIM:

a) To measure the pressure angle of the given gear
b) To measure the width of the tooth at pitch circle.
c) To measure depth of the tooth above the pitch circle.

APPARATUS: Gear tooth Vernier, Vernier caliper and gears.

PROCEDURE:

1. Find the zero error in the horizontal scale and vertical scale of the given gear tooth Vernier.
2. Find outer diameter of the given gear by using Vernier caliper.
3. Count the no of tooth on the given gear.
4. Calculate the diametral pitch, module,
5. Now the gear tooth, i.e. kept in between in the two jaws of the gear tooth Vernier.
6. Take the reading "a" (width) be the distance over X teeth and the reading "b" (depth) over X+Y teeth (average value).
7. Calculate the base pitch, base circle circumference, base circle diameter, pitch circle diameter and pressure angle of the gear by using the relations.
8. Similarly calculate the theoretical width at the pitch circle and depth of the gear tooth above pitch circle by substituting no of gear tooth and diametral pitch in the formula.

FORMULAE USED:

<u>OBSERVATIONS:</u>

A) DEPTH OF THE GEAR TOOTH:

S. No	Gear tooth	EXPERIMENTAL DEPTH					THEORITICAL THICKNESS (mm)	DEVIATION (mm)
		MSR (mm)	VSR (mm)	L.C (mm)	READING (mm)	Average reading (mm)		
1								
2								
3								

B) TOOTH THICKNESS OF THE GEAR TOOTH:

S. No	Spur Gear tooth	EXPERIMENTAL TOOTH THICKNESS					THEORITICAL THICKNESS (mm)	DEVIATION (mm)
		MSR (mm)	VSR (mm)	L.C (mm)	TOTAL READING	Average reading (mm)		
1								
2								
3								

Result:

ALLIGNMENT TEST ON LATHE MACHINE USING DIAL BORE INDICATORS

Exp.No: 3 **Date:**

AIM: To carry the alignment test on lathe for

1. Spindle axis parallel to bed.
2. Movement of upper slide parallel to bed.
3. Line of centers parallel to bed.
4. Tail stock parallel to bed.

APPARATUS: Dial indicator, mandrel, dial stand (magnetic type) etc.

Formula:

Deflection £ = $(WL^4) / (48\ EI)$

E	=	young's modulus
I	=	moment of inertia
W	=	volume* density
L	=	length of material
D	=	diameter of the mandrel

PROCEDURE:

I. SPINDLE AXIS PARALLEL TO BED:

1. For this test, a mandrel is fitted in the taper nose of the spindle which has a concentric taper shank which is close fit to the spindle nose taper.
2. The plunger of the dial indicator is pressed on the mandrel after keeping the magnetic stand of dial indicator on a suitable rest.
3. Now, the carriage is moved along and the deflection in the dial indicator is being noted.
4. In the horizontal plane, the mandrel is inclined to a direction opposite to the direction of tool pressure.
5. The indicator setup is very important else readings by pointer may be solely due to deflection of indicator mounting and it is difficult to detect and isolate deflection from true deflection.

II. MOVEMENT OF UPPER SLIDE PARALLEL TO BED:

1. Here also the mandrel is fitted in the taper socket of the spindle which has a concentric taper shank, which is a close fit to the spindle nose taper.
2. Here the dial indicator is fixed in the tool post.
3. The pointer of dial indicator is pressed on the mandrel after keeping the magnetic stand of dial indicator on a suitable rest.
4. Now, the upper slide of the carriage is being moved horizontally and the deflections given by dial indicator are noted.
5. The error is not tested in horizontal plane but in vertical plane because of provision of swiveling arrangement.

III. LINE OF CENTERS PARALLEL TO BED:

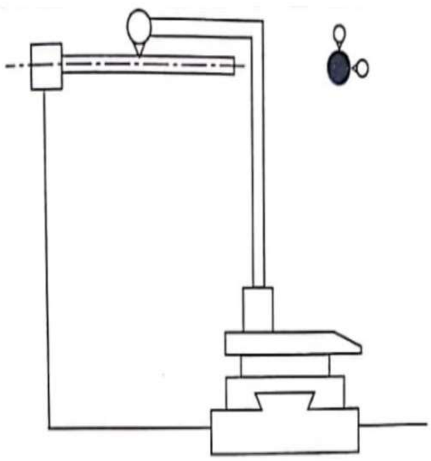
1. The mandrel is being fixed between the two centers.
2. To find out whether axes of both may be parallel to carriage but they may not coincide.
3. The dial indicator is fitted on the carriage and then the pointer is adjusted.
4. Press the mandrel in the vertical plane.
5. The carriage is moved horizontally and the error is being noted down.

IV. TAIL STOCK PARALLEL TO BED:

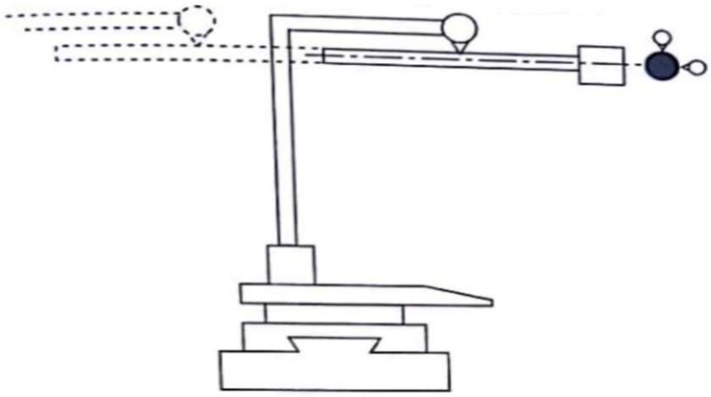
1. Fixing the dial indicator on the tool post and pressing carries out the test the plunger against the sleeves.
2. Then the carriage is moved along the full length of the sleeve, which will be rising towards the free end in vertical plane.
3. Then the deflections given by the dial indicator are noted down.

S.No	TEST	ERROR (mm/length)

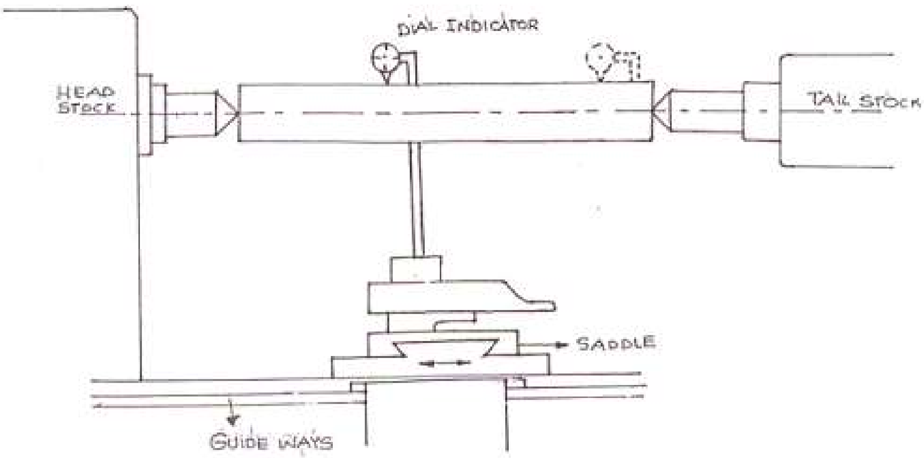
Parallelism of main spindle to the saddle movement



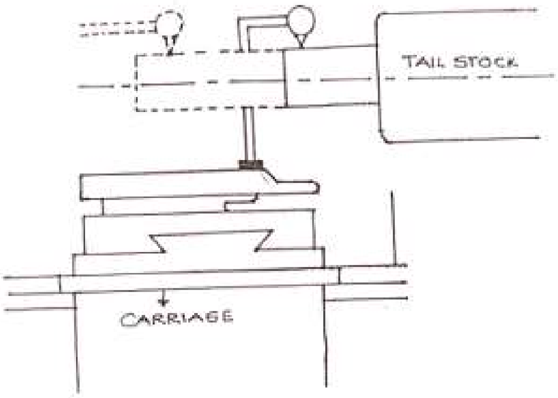
Parallelism of tailstock sleeve to saddle movement

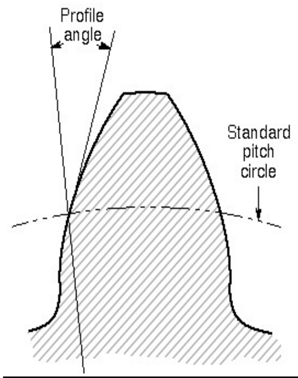


Line of Centres parallel to bed



Tail stock parallel to bed





RESULT:

STUDY OF TOOL MAKERS MICROSCOPE AND ITS APPLICATIONS

EXP. NO: 4 **Date:**

Aim: To measure the screw thread parameters of a given specimen using Tool Maker‟s Microscope.

Apparatus: Tool room microscope, screw thread.

Experimental setup:

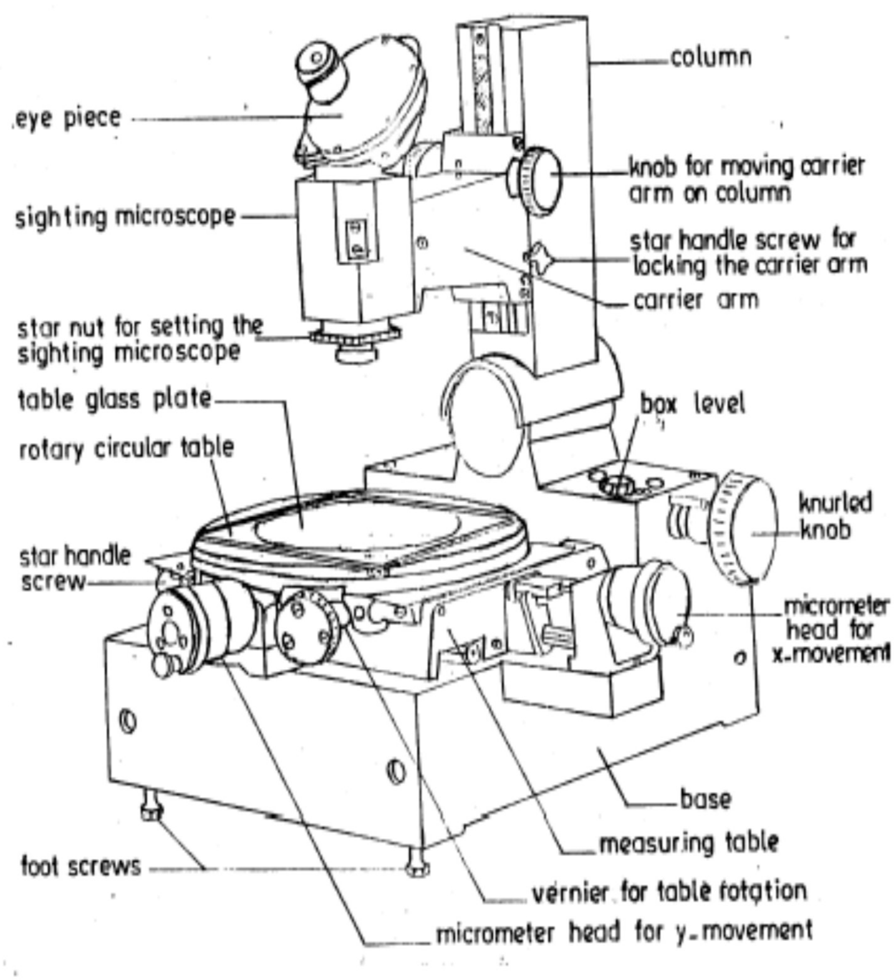


Fig. 1 Tool Makers Microscope

Theory: The large Tool Maker‟s Microscope (TMM) essentially consists of the cast base, the main lighting unit, the upright with carrying arm and the sighting microscope. The rigid cast base is resting on three foots screws by means of which the equipment can be leveled with reference to the build-in box level. The base carries the co-ordinate measuring table, consists of two measuring slides; one each for directions X and Y and a rotary circular table provided with the

glass plate (Fig.1). The slides are running on precision balls in hardened guide ways warranting reliable travel. Two micrometer screws each of them measuring range of 0 to 25 mm permit the measuring table to be displaced in the directions X and Y. The range of movements of the carriage can be widened up to 150 mm in the X direction and up to 50mm in the Y direction with the use of gage blocks.
The rotary table has been provided with 360 degrees graduation and with a three minute vernier. The rotary motion is initiated by activation of knurled knob and locked with star handle screw. Slots in the rotary table serve for fastening different accessories and completing elements.

The sighting microscope has been fastened with a carrier arm to column. The carrier arm can be adjusted in height by means of a rack and locked with star handle screw. Thread measuring according to the shadow image permits the column to be tilted in X direction to either side about an axis on centre plane level. The corresponding swivel can be adjusted with a knurled knob with a graduation cellar. The main lighting unit has been arranged in the rear of the cast base and equipped with projection lamp where rays are directed via stationary mounted mirror through table glass plate into the sighting microscope.

Nomenclature:

Spur gear: it is cylindrical gear whose tooth flanks are straight lines. A gear tooth is formed by portions of pair of opposed involutes.

Base circle: it is the circle from which involute form is generated.

Pitch circle: It is the imaginary circle used to specify the gear.

Tooth thickness: it is the arc distance measured along the pitch circle from the intercept on the flank on one flank to the intercept with another flank of the same tooth

Pressure angle: it is the angle between the line of action and the common tangent to the pitch circle

Measuring principle:

The work piece to be checked is arranged in the path of the rays of the lighting equipment. It produces a shadow image, which is viewed with the microscope eyepiece having either a suitable mark for aiming at the next points of the objects or in case of often occurring profiles. e.g. Threads or rounding – standard line pattern for comparison with the shadow image of the text object is projected to a ground glass screen. The text object is shifted or turned on the measuring in addition to the comparison of shapes.

The addition to this method (shadow image method), measuring operations are also possible by use of the axial reaction method, which can be recommended especially for thread measuring. This involves approached measuring knife edges and measurement in axial section of thread according to definition. This method permits higher precision than shadow image method for special measuring operations.

Applications

The large tool maker's microscope is suitable for the following fields of applications:

Length measurement in Cartesian and polar co-ordinates. Angle measurements of tools, threading tool punches and gauges, templates etc.

Thread measurements i.e., profile major and minor diameters, height of lead, thread angle, profile position with respect to the thread axis and the shape of thread. (Rounding, flattering, straightness of flanks)

Result:

ANGLE AND TAPER MEASUREMENT BY BEVEL PROTRACTOR AND SINE BAR

EXP. NO: 5 **Date:**

AIM: To measure the taper angle of a given work piece by using Sine bar

APPARATUS:

Sine bar, Rollers, Vernier calipers, Slip gauges, Surface Plate, Dial indicator with stand , angle plate , C – Clamp and Taper work piece.

PRINCIPLE:

Sine bar is based upon laws of trigonometry. To set a given angle one roller of the bar is placed on the surface plate and the combination of slip gauges is inserted under the second roller as shown in the figure.

If h is the height of the combination of the slip gauges, L is the distance between roller Centers.

Therefore, $\theta = \sin^{-1} (h/L)$

Then the angle can be measured as a function of sine. Thus, it is called sine bar.

PROCEDURE:

A) DIA OF THE ROLLER (D):

The first step in measuring the taper angle of the given work piece is to find the diameter of the roller, and the procedure is as follows

1. Sine bar is placed at any angle to the horizontal with the slip gauges, as shown in fig 1.
2. The dial gauge is brought in contact with the roller at three different position and the corresponding dial gauge readings are noted.
3. The average value of these readings is noted as height (H1).
4. Then remove the dial indicator from the setup and build suitable height of slip Gauges, to see that the top surface of the gauge block touches the dial indicator plunger and the height (H2) are noted.
5. The difference in height of the slip gauges gives us the diameter of roller.
6. Repeat the procedure 1 - 5 for another roller, and the average value from both the readings are noted as diameter of the roller.

B) LENGTH OF THE SINE BAR (L):

The second step is to determine the centre distance between two rollers, and the procedure is as follows.

1. Angle plate is placed on the surface plate.
2. The upper gauging surface of the sine bar should touch the surface of the angle plate by clamping as shown in fig 2.
3. The height over the top of the roller is determined with the help of slip gauges and noted as H3.
4. Then the centre distance between the rollers (L) is calculated by subtracting the dia of the roller from H3.

C) TAPER ANGLE OF THE GIVEN WORK PIECE (θ):

The taper angle of the given work piece is determined by the procedure is as follows

1. First, the given work piece is placed on the surface plate.
2. Sine bar is placed over the given work piece touching the upper surface of the work piece with the bottom surface of the sine bar, as shown in fig 3.
3. Then, build the pile of slip gauges under the roller until no air gap is observed between the gauge surface of sine bar and inclined surface of the work piece.
4. Then the height of the slip gauges is calculated and noted as " h".

Then the angle of the work piece is calculated by the relation

$\sin\theta = h/L$

Where h = height of slip gauges

L = length of the sine bar.

OBSERVATIONS:

A) DIA OF THE ROLLER (D):

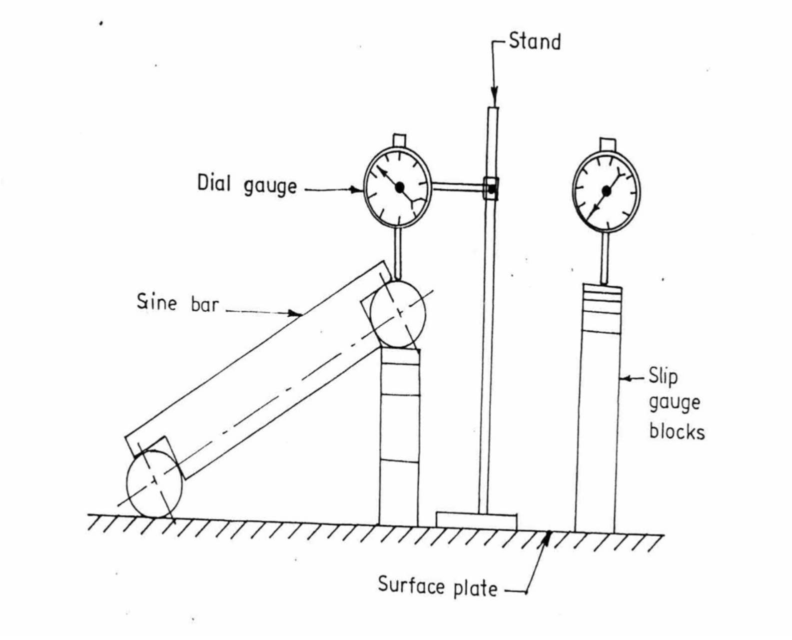
S.No	Height H1 (mm)	Height H2 (mm)	DIA OF THE ROLLER (D) D = H2 – H1 (mm)
1			
2			
3			

B) LENGTH OF THE SINE BAR (L):

S.No	Height H3 (mm)	LEMGTH OF SINE BAR L = H3 – D (mm)
1		
2		
3		

C) TAPER ANGLE OF THE GIVEN WORK PIECE:

S.NO	Specimen	HEIGHT OF SLIP GAUGES "h" (mm)	Sin θ = h/L (deg)	Average value of θ (deg)
1				
2				



ig.1 Measurement of dia of roller

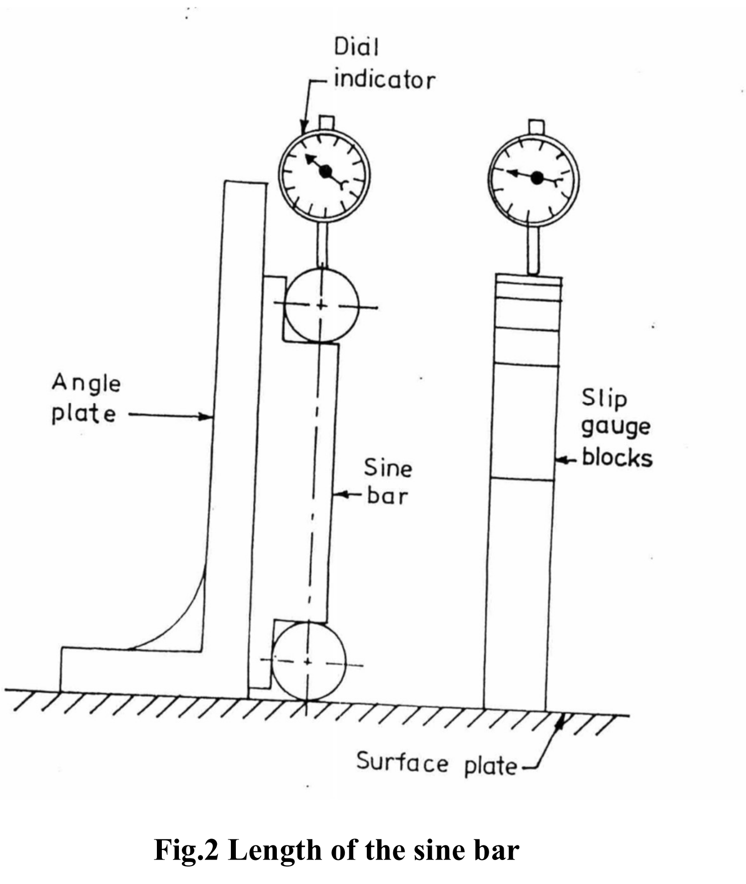


Fig.2 Length of the sine bar

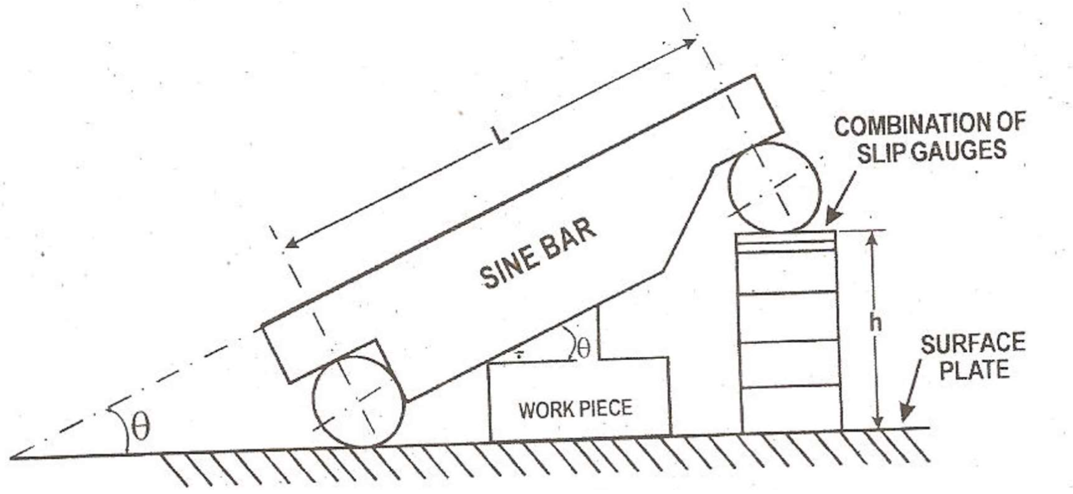


Fig.3 Measurement of taper angle of the work piece

RESULT:

Thus the taper angle of the given specimen is measured using sine bar.

The external taper angle is ________________________

THREAD MEASUREMENT BY TWO WIRE/THREE WIRE METHOD

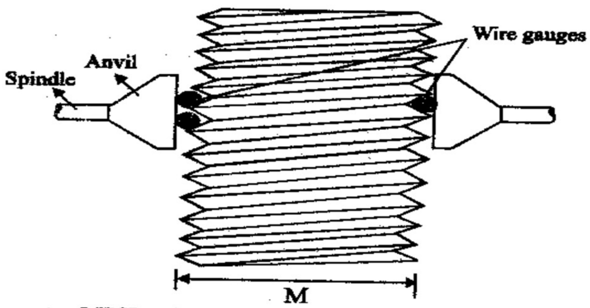
Exp.No:6 **Date:**

Aim: To find the effective diameter of a given screw thread by three wire method.

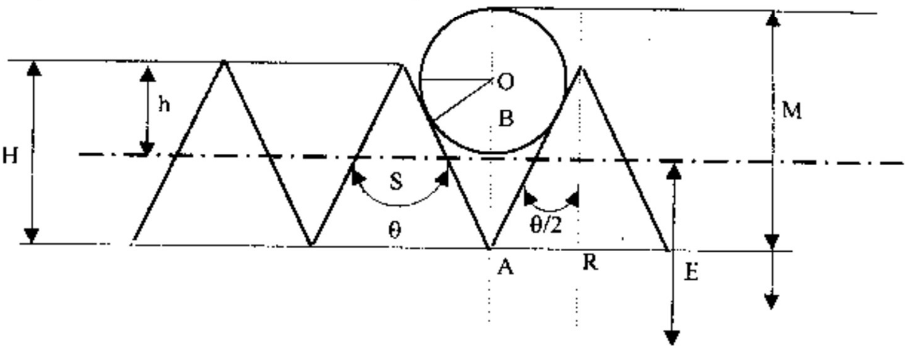
Apparatus: Three wires of same diameter, flanged micrometer, thread specimen.

Theory: This method of measuring the effective diameter is an accurate method. In this three wires or rods of known diameter are used: one on one side and two on the other side. This method ensures the alignment of micrometer anvil faces parallel to the thread axis.

Best size wire: Best size wire has a diameter which makes contact with the flanks of the thread on pitch line, since effective diameter wire which makes contact on the true flank of the thread.



Measurement of Effective Diameter by three wire method.



Procedure:

1. Find out the pitch of the given thread specimen.
2. Select the suitable wire. The diameter of the wire depends upon the pitch.
3. Note down the diameter of the wire.
4. Keep one wire on one side and the other two wires on the opposite side of the flange between the two flanks of micrometer as shown in the sketch.
5. Find out the dimension over the wires.
6. Find out the dimension under the wires using the formula.
7. Find the effective diameter of the wire using the formula.

Specimen Calculations:

1. d = diameter of the wire

r = radius of the wire.

p = pitch of the thread.

M = Measurement over the wire.

E = Effective diameter

D = Outside diameter of the thread specimen

2. $$E = M - d\left(1+\operatorname{cosec}\frac{\theta}{2}\right)+\left(\frac{p}{2}\right)\cot\frac{\theta}{2} \quad \text{mm}$$

Where θ = Thread angle.

In case of Whit Worth thread

$\theta = 55^0$

In case of Metric thread

$\theta = 60^0$

Diameter of best size wire is given by

$$d = \frac{p}{2\cos\left(\frac{\theta}{2}\right)}$$

Result:

Effective diameter of the given thread =

SURFACE ROUGHNESS MEASUREMENT BY TALYSURF INSTRUMENT

Exp.No:7 **Date:**

AIM: To Measure the surface roughness of the given surfaces using TalySurf.

APPARATUS: Sample surfaces, surface plate and TalySurf instrument.

PROCEDURE:

1. Check the surface plate for flatness and straightness.
2. Place the sample surface to be tested on the surface plate.
3. Traverse the stylus on the surface of the specimen.
4. Note down the roughness measurements in the tabular column.

PRECAUTIONS:

1. Traverse the stylus smoothly on the surface without jerk be careful by handling instrument

Sl. NO.	Specimen	Ra	Average (µm)	Ry (µm)	Average (µm)	Ry (µm)	Average (µm)
1.	5% Si-Al Alloy						
2.	10% Si-Al Alloy						
3.	Slip Gauge						

RESULT:

SPECIMEN-1:

Ra = **Ry =** **Rz =**

SPECIMEN-2:

Ra = **Ry =** **Rz =**

SPECIMEN-3:

Ra = **Ry =** **Rz =**

SECTION B

MEASUREMENTS

CALIBRATION OF PRESSURE GAUGE

Exp.No:1 **Date:**

AIM : Calibration of pressure transducer.

Apparatus Required :Pressure Transducer,

Pressure Indicator

Pressure source. (Manually operated Foot pump)

Theory: Pressure is basically a mechanical concept that can be expressed in terms of the primary dimensions of mass and length, and is a physical parameter encountered in many fields. It is defined as the force acting per unit area, measured at a given point or over a surface. This can be in absolute, gauge, or differential units, depending upon the reference taken. The measurement involved can be of a static or dynamic nature. The unit for pressure is expressed as gravitational units of force per unit area, and the magnitudes, the parameter is expressed in terms of cm of water column or mm of mercury at 0^oC. In SI units, the magnitude is expressed in Pascal's (N/m^2).

The principles used in the measurement of pressure are also, applied in the measurement of LOAD/STRAIN. Pressure is represented as force/unit area. As such it may be considered as a type of stress. Since stress is also defined as force per unit area. In this section the term 'Pressure' refers the force per unit area exerted by a fluid.

Pressure transducer is flat diaphragm type which is made by stainless steel and foil type strain gauges are bonded on the surface of the diagram in the form of bridge and Force/ Pressure will be applied on the other side of the diaphragm. Excitation voltage to the bridge is supplied from instrument. Deflection in the diaphragm causes change in O/P signal of the bridge. This O/P signal is feed to the highly sophisticated Amplifier. This amplified signal is given to the A/D convert the Analog signal to Digital. This O/P is feed to the 3 ½ digit Digital panel Meter (D.P.M.) to read the pressure directly in Kg/cm^2.

Procedure:

1. Connect the mains chord to the 230 V/50 Hz Ac supply.
2. Connect the sensor to the sensor socket provided at the front panel.
3. Switch On the Instrument.
4. Set the ZERO pot to 00.00 (i.e., Balance the Bridge.)
5. Check the Analog Pressure gauge & Pressure Transducer were mounted properly or not.
6. Lightly tight the 'Release Valve' to rotate Clockwise direction.
7. Apply the pressure by pressing the Handle which is mounted on Drum. (i.e., Upward and Downward direction).

8. Compare the pressure gauge reading & Digital Indicator readings.
9. To decrease the Pressure slowly loose the ‘Release Valve’ to rotate anti- clockwise direction.
10. Cal POT given for maximum reading
11. Now the Indicator shows the reading in 3 ½ digit seven segment display.
12. Plot a graph for applied Pressure v/s Indicator.

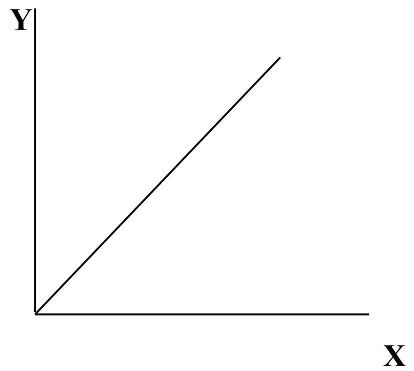
Precaution:

Don’t increase the pressure more than 3Kg/cm^2. because pressure gauge will operate only 45% of the full scale reading. If more than 45% of the pressure applied, gauge will spoil.

Tabular Column:

Sl. No.	Applied Pressure in Kg/Cm^2	Indicated Readings in Kg/Cm^2

GRAPH: Applied Pressure V/S Indicated Readings.



X - Axis Pressure Gauge Reading.

Y – Axis Indicated Readings.

Result:

STUDY AND CALIBRATION OF MCLEOD GAUGE FOR LOW PRESSURE

Exp.No:2 **Date:**

AIM : Low pressure measurement by using McLeod gauge.

APPARATUS REQUIRED:

1. McLeod Gauge,
2. Vacuum chamber,
3. Vacuum pump.

THEORY:

LOW PRESSURE GAUGE:

Pressure less than 1 mm of mercury are considered to be low pressure, and are expressed in either of the two units, namely the torr and micron. One torr is a pressure equivalent to 1mm Hg at standard conditions; one micron is 10^{-3} torr through common usage the term vacuum refers to any pressure below atmosphere (760 mm Hg). This Pressure region is divided in to five segments.

Low vacuum 760 torr or 25 torr.

Medium vacuum 25 torr to 10^{-3} torr.

High Vacuum 10^{-3} to 10^{-6} torr.

Very high vacuum 10^{-6} to 10^{-9} torr

Ultra high vacuum 10^{-9} torr and beyond.

The pressure measuring devices for low pressure (vacuum) measurement can be classified into two groups.

i) DIRECT MEASUREMENT: Where in displacement deflection caused by the pressure is measured and is correlated to the applied pressure. This principal is incorporated in manometers, spiral bourdon tube, flat and corrugated diaphragms and capsules. Manometers and below gauges are suitable to about 0.1 torr, bourdon gauges to 10 torr, and diaphragm gauges to 10^{-3} torr. Below these ranges, that use of indirect vacuum gauges is resorted to.

ii) INDIRECTMEASUREMENT **:-** (Inferential) Gauges where in the low pressure is detected through measurement of a pressure controlled property such as volume, thermal conductivity etc. The inferential gauge includes McLeod vacuum meters. Attention would be concentrated here on low- pressure measurement by the inferential gauges only.

iii) MCLEOD GAUGE :The unit comprises a system of glass tubing in which a known volume of gas at unknown pressure is trapped and then isothermally compressed by a rising mercury Column . This amplifies the unknown pressure and allows its measurement by conventional manometric means of measurement.

PROCEDURE:

1. Connect the tubes (pipes) from vacuum pump to vacuum chamber and vacuum chamber to McLeod Gauge.
2. Open the outlet valve before starting the vacuum pump.
3. Close the outlet valve after starting the vacuum pump.
4. Keep the McLeod Gauge horizontal position before starting the vacuum pump.
5. Switch on the Vacuum pump.
6. See the readings in McLeod Gauge by varying perpendicular axis and note down the reading.

PRECAUTIONS:

1. Keep the McLeod Gauge horizontal position before starting the vacuum pump.
2. Note down the reading without parallax error.

TABULAR COLUMN:

Sl. No.	McLeod gauge reading.	Digital Piranigauge reading	Analog vacuum gauge pump reading

RESULT:

CALIBRATION OF TRANSDUCER OR THERMOCOUPLE FOR TEMPERATURE MEASUREMENT

Exp.No:3 **Date:**

AIM : Calibration of Temperature using Thermistor.

APPARATUS REQUIRED : Thermistor

Digital Temperature Indicator

Heat Source (Electrical Sterilizer)

Thermometer

THEORY: Thermistor is a contraction of term "thermal resistors". Thermistors are generally composed of semi- conductor materials. Although positive temperature coefficient of units (which exhibit an increase in the valve of resistance with increase in temperature) are available, most thermistor have a negative temperature coefficient of resistance can be as large as several percent per degree Celsius. This allows the thermistor circuits to detect very small changes, this temperature which could not be observed with an RTD or a thermocouple, in some cases the resistance of thermistor at room temperature may decrease as much as5% for each 1^0c rise in temperature. This high sensitivity to temperature changes makes thermistor extremely useful for precision temperature measurements control and compensation.

Thermistors are widely used in applications which involved measurement in the range of -60^0c to 15^0c the resistance of thermistor ranges from 0.50 ohms to 0.75 M ohms .Thermistor is a highly sensitive device. The price to be paid off for the high sensitivity is in terms of linearity. The thermistor exhibits a highly non linear characteristic of resistance verse temperature.

Thermistors are composed of sintered mixture of metallic oxides such as manganese , nickel , copper , iron and uranium they are available in variety of sizes and shapes .The thermistor may be in the form of beads , road and shapes .The thermistor has a very high –ve temperature of resistance making it an ideal temperature transducer.

PROCEDURE:

1. Connect the sensor cable to the sensor point in Front panel of the instrument.
2. Switch on the instrument.
3. Set the minimum temperature while sensor keeping to the cold water.
4. Adjust the maximum temperature while boiling the water by help of maximum Pot.
5. Note down Reading.
6. Compare reading of Thermometer and indicator Reading.
7. Make a graph.

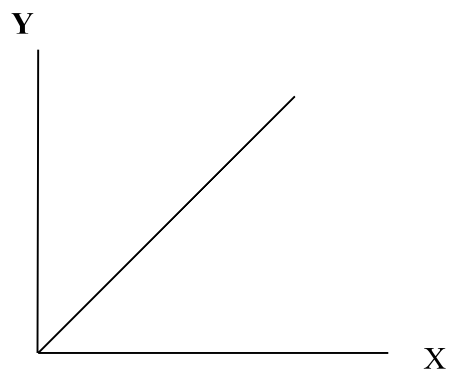
PRECAUTIONS:

1. Place thermometer and thermistorside by side while measuring.
2. Do not boil the water up to boiling point.

OBSERVATION TABLE:

SL NO.	Thermometer Readings in ^{0}C	Indicated Readings in ^{0} C

Graph :- Thermometer Reading v/s Indicated Readings



X - Axis Thermometer reading.

Y - Axis Indicated Readings.

RESULT:

CALIBRATION OF LVDT TRANSDUCER FOR DISPLACEMENT MEASUREMENT

Exp.No:4 **Date:**

AIM:To determine the characteristicof LVDT(Linear variable differential transformer).

APPARATUS REQUIRED : LVDT,

Digital Displacement Indicator,

Calibration Jig (with micrometer).

THEORY : The most widely used inductive transducer to translate the linear motion into electrical Signals are the linear variable differential transformer (LVDT). The basic construction of LVDT is shown in fig;

The transformer consists of a single primary P & two secondary windings S1 & S2 wound on a cylindrical former. The secondary windings have equal number of turns & are identically placed on either side of primary windings. Have equal number of turns & are identically placed on either side. A moveable soft iron core is placed inside the transformer. The displacement to be measured is applied to the arm attached to the Soft iron core. In practice this is made of highly permeability, nickel iron which is Hydrogen annealed.

This gives low harmonics low null voltage and high sensitivity. This is slotted longitudinally to reduce eddy current losses. The assembly is placed in a stainless steel Housing & the end leads provides electrostatic & electromagnetic shielding. The frequency of A.C. applied to primary windings may be between 50 Hz to 20 kHz.

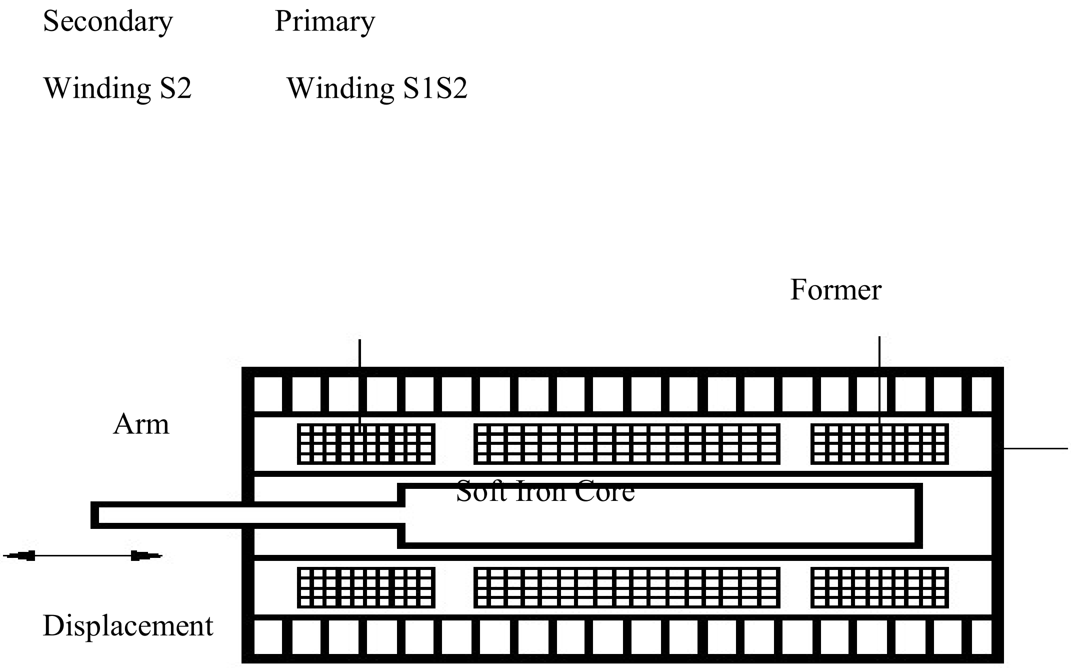
Since the primary windings are excited by an alternating source, it produces an alternating magnetic field which in turn induces alternating current voltage in the two Secondary windings.

The output voltage of secondary, S_1 is Es_2. In order to convert the output is from S_1& S_2 into a Single voltage signal, the two secondary's S_1& S_2 are connected in series opposition as shown Fig:- (b) . Thus the output voltage of the transducer is the difference of the two voltages.

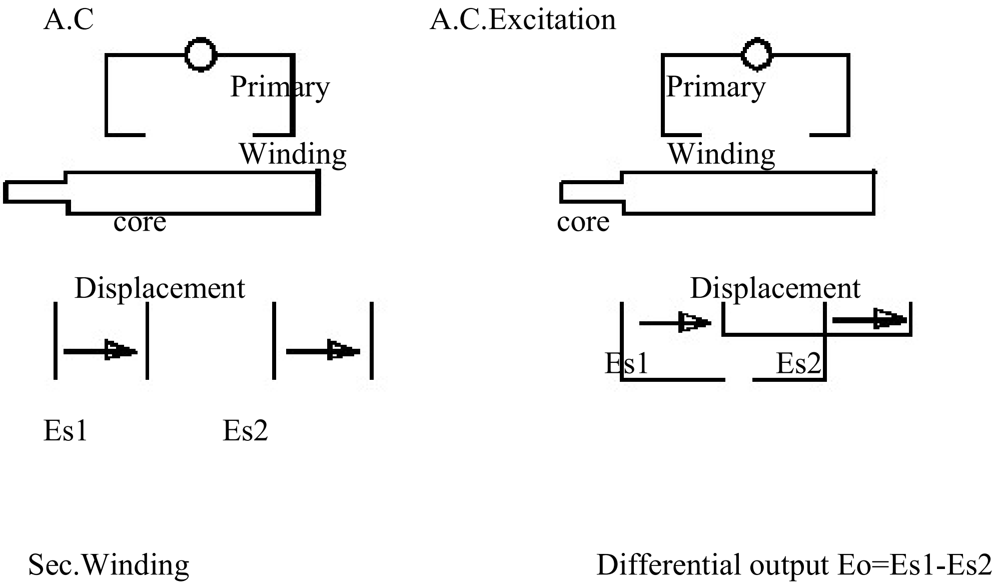
Differential output voltage.

$E_0 = Es_1 = Es_2$

When the core is at its normal (NULL) position, the flux linking with both the secondary windings is equal & hence equal emfs are induced in them.



Thus at null position: $Es_1 = Es_2$. Since the output voltage of the transducer is the difference of the voltage, the output voltage E_0 is zero at null position.



Now if the core is moved to the left of the NULL position, more flux links with windings S_1' & less with windings S_2. According output voltage Es_1' of the secondary windings S_1 , is more than Es_2 , the output voltage of secondary windings S_2 . The magnitude of output voltage. Similarly, If the core is moved to the right of the null position, the flux linking with winding S_2 becomE larger than that linking with windings S_1 Thus results in Es_2 becoming larger than Es. The output voltage in this case is EO= Es - Es & is 180' out of the phase with the primary voltage. Therefore, the two differential voltages are 180' out of phase with each.

The amount voltage change in either secondary winding is proportional to the amount movement of the core. Hence, we have an indication of amount of linear motion. By noting which output voltage is increasing or decreasing, we can determine the direction of motion. In other words any physical displacement of the core cause the voltage of one secondary winding to increase while simultaneously reducing the voltage in the other secondary winding. The difference of the two voltages appears the output terminals of the transducer and gives measure of the physical position of core hence the displacement.

PROCEDURE:

1. Plug power chord to Ac mains 230 V 50 Hz. And switch on the instrument.
2. Balance the amplifier with the help of zero knob so that display should read Zero (00.00) without connecting the LVDT to instrument.
3. Connect the LVDT cable to instrument.
4. Make mechanical zero by rotating the micro meter. Display will read (00.00). This is null Balancing.
5. Give displacement with micrometer and observe the digital readings.
6. Plot the Graph of Micrometer reading v/s Digital reading.

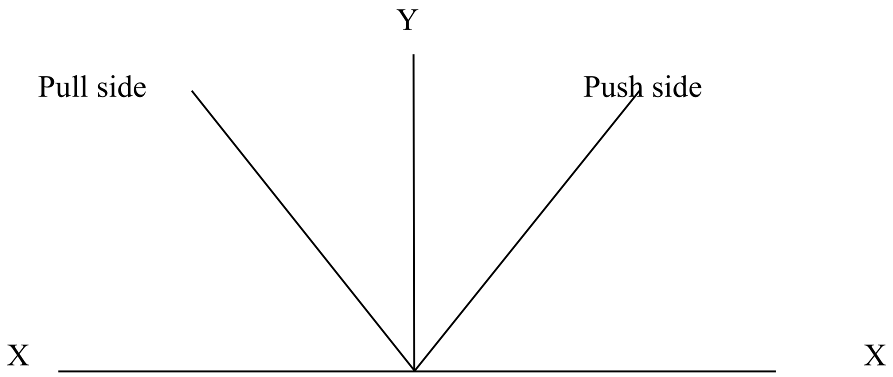
PRECAUTIONS:

1. Give slow displacement to micrometer and observe the digital readings carefully.
2. Do not move the micrometer to the end position.

Tabulation:

Push Side +ve readings			Pull Side –Ve readings	
Sl. No.	Micrometer Readings in mm	Indicated Readings in mm	Micrometer Readings in mm	Indicated Readings in mm

Graph: MICROMETER READING V/S INDICATED READING.



X - Axis Micrometer Reading

Y - Axis Indicated Reading.

RESULT:

CALIBRATION OF CAPACITIVE TRANSDUCER FOR ANGULAR MEASUREMENT

Exp.No: 5 **Date:**

AIM: To study the capacitance transducer for Measure Displacement.

APPARATUS REQUIRED: Digital displacement indicator,

Capacitance pick up.

THEORY: Capacitor comprises two or more metal plate conductors separated by insulators, as voltage is applied across the plates equal and opposite electric charges are generated on the plates. The capacitance transducers operates on the principle of a variation in the capacitance produced by the physical quantity being measured these are used for both linear and angular measurements.

For this measurement considered two metal plate conductors and one is fixed and other is movable in rotary manner on the first plate, then that displacement change is displayed in terms of capacitance.

PROCEDURE:

1. Keep the movable capacitance transducer at 0^0 point and make Zero by help of minimum pot.
2. Take the reading to move from 0^0 -270^0.
3. And make a graph protractor reading Vs indicating reading.

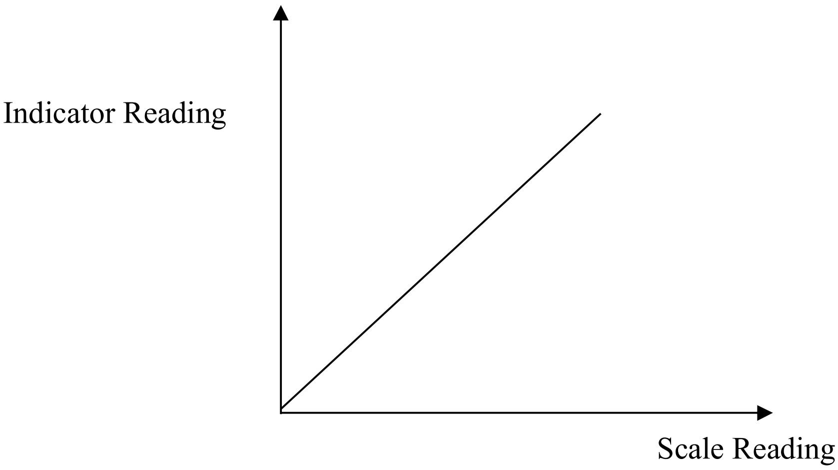
PRECAUTIONS: -

1. Keep the movable capacitance transducer at 0^0 point and make Zero by help of minimum pot.
2. Give slow displacement to the movable capacitance transducer.
3. Avoid parallax error.

TABULAR COLUMN:

S.No	PROTRACTOR READING	INDICATED READING

GRAPH:-



RESULT:

CALIBRATION OF PHOTO AND MAGNETIC SPEED PICKUPS FOR THE MEASUTREMENT OF SPEED

Exp.No: 6 **Date:**

AIM: Calibration of Photo sensor and Magnetic Sensor for measuring speed of the motor.

APPARATUS REQUIRED : Digital speed Indicator, Motor,
Photo sensor,Magnetic sensor.

THEORY: Digital speed indicator is microprocessors circuit design with high accuracy, digital read out. It is ideal inspecting and measuring the speed of moving gears fans centrifuges, pumps, Motors and other equipments. It is non-contact sensing devices photo optical and magnetic / Proximity type sensors. It will take signals from this sensor and this signals will I/P to the indicator and that signal will coverts is to actual RPM of the Motor . And the indicator will indicate the reading in RPM directly.

PROXIMITY SENSOR / MAGNETIC SENSOR

It is non- contact sensing device it sensor to the signals from Rotating body, and is very accurate , and very reliable and this sensing device is non-contact / type an it is equal to magnetic pick up.

OPTICAL / PHOTO PICK UP:

It is non-contact sensing device it senses to the signals from Rotating body, and is very accurate, and it gives better output from the rotating body. And very reliable and this sensing device is non contact type and it is equal to photo device.

PROCEDURE:

1. Connect the main chord to the 230 v / 50 Hz AC supply.
2. Connect the sensor socket provided atthe front panel photo/magnetic.
3. Switch on the Instrument.
4. Switch on the motor and vary the speed of the motor in different speed.
5. Note the reading given the Tabular column by switching the sensor socket provided at the front panel photo/magnetic.

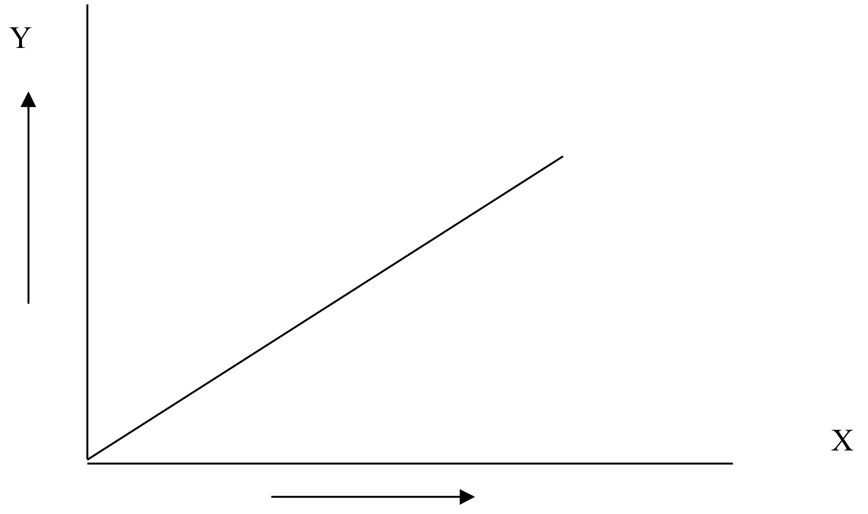
PRECAUTIONS:

1. Slowly vary the speed of the motor in different speeds.
2. Take readings by switching the sensor socket provided at the front panel photo/magnetic.

TABULATION:

S.NO	PHOTO SENSING DEVICE READING	MAGNETIC SENSING DEVICE READING.

Graph: speed photo sensor Vs magnetic sensor.,



RESULT:

STUDY AND USE OF A SEISMIC PICKUP FOR THE MEASUREMENT OF VIBRATION AMPLITUDE OF AN ENGINE BED AT VARIOUS LOADS

Exp.No:7 **Date:**

AIM: To study the piezoelectric accelerometer for themeasurement of vibration parameters of an engine bed at various points.

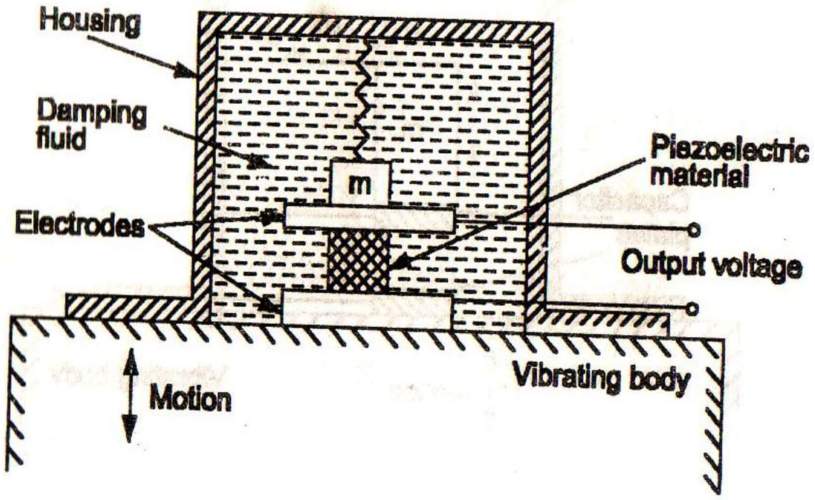
APPARATUS : 1. Vibration indicator.

2. Vibration Exciter and its connecting wire and socket.

3. An external filter.

THEORY: The study and measurement of vibration in any structure or machine is of paramount importance for the following reasons:

1. Undesirable vibration is a waste of energy and causes wear & subsequent break-down resulting in high maintenance costs.
2. The noise produced due to vibrating bodies or structures cause human fatigue resulting in reduced efficiency.
3. Undamped vibrations transmitted to structures might excite vibrations at natural frequencies and cause permanent damage. The Accelerometer Model is a piezoelectric vibration sensor. When the piezoelectric element in the sensor is strained by an external force displaced electric charges accumulate on opposing surfaces forming a charge proportional to the force. This electric charge when applied to a very high impedance amplifier produces a voltage signal proportional o the acceleration to which the piezoelectric element is subjected to. With this unique configuration vibrating frequencies of near D.C up to 3000Hz can be very easily measured. Buffer amplifiers, integrators and equalizers built in the Vibration Indicator help to measure Vibration displacement, velocity and acceleration just by operating a rotary switch. Both Ac &Dc recorder outputs are calibrated, buffered and brought to the recorder terminals facilitating easy recording



PROCEDURE:

1. Mount the vibration sensor rigidly on the vibration body as shown in Fig.6. All the details given must be meticulously followed to obtain accurate results. If the vibrating specimen is magnetic then the magnetic mounting base can be used to mount the sensor on the vibrating body. In this case the highest frequency of operation is reduced to 1000 Hz.
2. Clamp the cables to the vibrating body, this is essential to avoid cable whip and subsequent damage to the cable.
3. Keep the vibration indicator in a suitable place and connect the power cord.
4. Interconnect the Accelerometer and Vibration indicator using the cable provided with the accelerometer.
5. Connect recorders or oscilloscopes to the appropriate output terminals as required.
6. Keep "IN/OUT" switch on the rear panel in position OUT.
7. Select the parameter of interest on the function switch.
8. To start with select RANGE C.
9. Switch "ON" the instrument and wait for one minute for the capacitors to get charged.

Now, the indicator is ready for making vibration measurements.

10. Select range A if the reading is below 20 when measuring Acceleration or velocity and 200 while measuring displacement.
11. Select range B for vibration levels between 20 and 200 for acceleration and velocity and between 200 and 2000um for displacement.
12. Select range C for vibration levels beyond 200 for acceleration and velocity and beyond 2000um for displacement.
13. The readings indicated are RMS values for acceleration and velocity and peak to peak for displacement and the units are indicated by the LED's adjacent to the display window.

PRECAUTIONS:

1. Do not accelerate the sensor with large amplitude.
2. Take the readings without parallax error.

Tabular column: Amplitude pot at maximum level

SL. NO.	FREQUENCY H Z	DISPLACEMENT microns	VELOCITY mm/sec	ACCELERATION m/sec^2

RESULT:

SECTION B ADDITIONAL EXPERIMENT

STUDY OF WATER FLOW RATE BY USING ROTOMETER

Exp.No:1 **Date:**

AIM:To Study the water Flow rate by using Rotameter.

Apparatus Required : Rotameter,
Water Tanks,
Water Pump with total set up,
Stop watch etc.

THEORY: A Rotameter is a constant – pressure drop, variable area Flow meter. It consists of a vertical tapered tube with a float which is free to move within the tube. A Rotameter is shown in the equipment which uses a glass tube.

The fluid flows through the tube from bottom to the top. When no fluid is flowing, the Float rests at the bottom of the tube. The float is made of such a diameter that it completely blocks the inlet (small end of tube). When a flow starts in the pipe line and the fluid reaches the float, the buoyant effect of fluid makes the float lighter. Usually, the float has a density greater than that of the flowing material so that the buoyant effect alone is not sufficient to lift the float. The float passage remains closed until the pressure of the flowing material, plus the fluid buoyancy effect, exceeds the downward pressure due to the weight of the float. The float then rises and floats within the flowing medium in proportion to the flow at the given pressure.

As the float moves upward towards the larger end (outlet) of the tapered tube, an annular passage is opened between the inner wall of the glass tube and the periphery of the float. This forms a concentric opening through which the flowing material passes as shown in equipment. The float continues to rise until the annular passage is large enough to pass all the material coming through the pipe. The fluid or gas velocity pressure falls until this plus the fluid or gas buoyant effect exactly equals the weight of the float (or the gravitational force exerted by float). The float then comes to a dynamic equilibrium.

Additional increase in flow rate causes the float to rise higher in the tube. The decrease in flow rate causes the float to sink (or come down) to a lower level. This means that every float position corresponds to one particular flow rate. The float gives a reading on a calibrated scale etched on the glass tube, and the flow rate can be determined by direct observation of the metering float.

PROCEDURE:

1. Fill the water at least 75% of the reservoir water tank.
2. Connect the power chord to 230V mains.
3. Keep water flow valve in close position means clock wise direction.
4. Switch on the water Pump.
5. Slowly open the water flow valve position means turning in anti clock wise direction.
6. The manometer Readings can be note down.
7. Like that you can take the different readings.
8. Note down Rotameter reading in LPM.

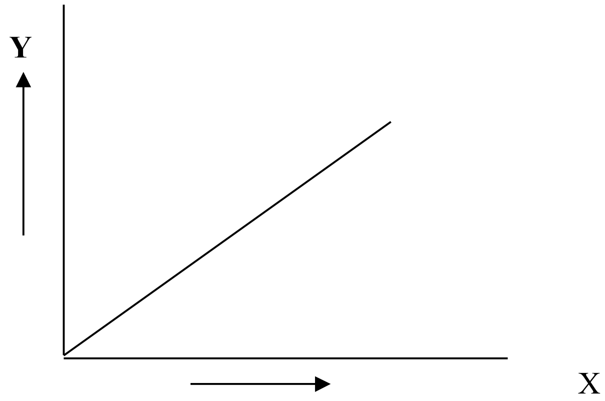
PRECAUTIONS:

1. Fill the water at least 75% of the reservoir water tank.
2. Note down Rotameter reading without parallax error.

Tabular Column:

Sl. No.	ROTAMETER READING in LPM	TIME in sec	h in meter	$Q_{act} = \frac{A \times h}{t}$

Graph: Rota meter Reading on Y-axis Vs Actual Reading on X-axis



RESULT: