lendi

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

STUDENT MANUAL
MECHANICAL MEASUREMENTS & METROLOGY LAB

B.Tech -
Mechanical Engineering

Department of Mechanical Engineering

Mechanical Measurements and Metrology

LAB MANUAL

For

MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
(Approved by A.I.C.T.E & Affiliated
to JNTU-GV, Accredited by NAAC
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DEPARTMENT OF MECHANICAL ENGINEERING

MECHANICAL MEASUREMENTS AND METROLOGY

LAB MANUAL

DEGREE	B.Tech(U.G)
NAME OF THE LAB WITH CODE	**Mechanical Measurements and Metrology Lab** R20MEC-PC3206
REGULATION	R20
PROGRAM	**MECHANICAL ENGINEERING**
YEAR&SEMESTER	III B.TECH II SEM
COURSEAREA/ DOMAIN	DESIGN
CREDITS	1.5

INSTITUTE

VISION

- Producing globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behavior of students towards employment and higher studies.

- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.

- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

lendi Institute of Engineering & Technology
An Autonomous Institution
Accredited by NAAC with " A" Grade, Accredited by NBA (ECE, CSE.EEE & MECH)
Approved by A.I.C.T.E. & Permanently Affiliated to J. N. T. U. Gurajada, VIZIANAGARAM
Via 5th APSP Battalion, Jonnada (V), Denkada (M), NH-3, Vizianagaram Dist - 535005, A.P. Website : www.lendi.org
Ph : 08922-241111, 241666, Cell No : 9490344747, 9490304747,e-mail : lendi_2008@yahoo.com

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Envisions Mechanical Engineers of highly competent and skilled professionals to meet the needs of the modern society.

MISSION

- Providing a conductive and inspiring learning environment to become competent engineers.
- Providing additional skills and training to meet the current and future needs of the industry.
- Providing a unique environment towards entrepreneurship by fostering innovations, creativity, freedom and empowerment.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will have strong knowledge and skills and attitudes towards employment, higher studies and research.
PEO2: Graduates shall comprehend latest tools and techniques to analyze, design and develop novel systems and products and solutions for real life problems.
PEO3: Graduates shall have multidisciplinary approach, professional attitude and ethics, good communication and teamwork and engage in life-long learning and professional development to adapt to rapidly changing technology.

PROGRAM OUTCOMES(POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: 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.

PO3: 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.

PO4: 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.

PO5: 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.

PO6: 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.

P07: 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.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

P09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: 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.

PO12: 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)

PSO1: Capable of design, develop and implement sustainable mechanical and environmental systems.

PSO2: Qualify in national and international competitive examinations for successful higher studies an employment.

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COURSE DATA SHEET

PROGRAM: Mechanical Engineering	DEGREE: B Tech
COURSE: METROLOGY & INSTRUMENTATION LAB	SEMESTER: III - II CREDITS: 2
COURSE CODE:R20MEC-PC3206 REGULATION: R 20	COURSE TYPE: Core
COURSE AREA/DOMAIN: ALLIED	CONTACT HOURS: 3 hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY):	LAB COURSE NAME (IF ANY): NA

SYLLABUS:

Experiment	DETAILS **METROLOGY & INSTRUMENTATION LAB**	HOURS
1	Measurement of lengths, heights, diameters by vernier calipers, micrometers etc.	3
2	Measurement of bores by internal micrometers and dial bore indicators.	3
3	Use of gear tooth vernier caliper for tooth thickness inspection and flange micro meter for checking the chordal thickness of spur gear	3
4	Machine tool alignment test on the lathe.	3
5	Angle and taper measurements with bevel protractor, Sine bars, rollers and balls.	3
6	Use of spirit level in finding the straightness of a bed and flatness of a surface.	3
7	Thread inspection with two wire/ three wire method & tool makers microscope.	3
8	Surface roughness measurement with roughness measuring instrument.	3
	INSTRUMENTATION LAB	
9	Calibration of pressure gauge.	3
10	Calibration of transducer for temperature measurement	3
11	Study and calibration of LVDT transducer for displacement measurement.	3
12	Calibration of strain gauge.	3

13	Calibration of capacitive transducer	3
14	Study and calibration of photo and magnetic speed pickups.	3
15	Study and calibration of a rotameter.	3
16	Calibration of resistance temperature detector.	3
	TOTAL HOURS	36

Experiments Conducted in Laboratory:

Experiment	DETAILS Mechanical Measurements and Metrology Lab	CO Mapping	HOURS
	Introduction class		3
1	Measurement of lengths, heights, diameters by vernier calipers, micrometers etc.	CO1, CO2, CO3	3
2	Measurement of bores by internal micrometers and dial bore indicators.	CO1, CO2, CO3	
3	Use of gear tooth vernier caliper for tooth thickness inspection and flange micro meter for checking the chordal thickness of spur gear	CO1, CO2, CO3	3
4	Machine tool alignment test on the lathe.	CO1, CO2, CO3	3
5	Angle and taper measurements with bevel protractor, Sine bars, rollers and balls.	CO1, CO2, CO3	3
6	Use of spirit level in finding the straightness of a bed and flatness of a surface.	CO1, CO2, CO3	3
7	Thread inspection with two wire/ three wire method & tool makers microscope.	CO1, CO2, CO3	6
8	Surface roughness measurement with roughness measuring instrument.	CO1, CO2, CO3	3
	INSTRUMENTATION LAB		3
9	Calibration of pressure gauge.	CO4, CO5	3
10	Calibration of transducer for temperature measurement	CO4, CO5	3
11	Study and calibration of LVDT transducer for displacement measurement.	CO4, CO5	3
12	Calibration of strain gauge.	CO4, CO5	3
13	Calibration of capacitive transducer	CO4, CO5	3
14	Study and calibration of photo and magnetic speed pickups.	CO4, CO5	3
15	Study and calibration of a rotameter.	CO4, CO5	3
16	Calibration of resistance temperature detector.	CO4, CO5	3
	Internal examination		
	TOTAL		**48**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	Engineering Metrology by R.K.Jain / Khanna Publishers
T	Engineering Metrology by Mahajan / Dhanpat Rai Publishers
R	Dimensional Metrology, Connie Dotson, Cengage Learning. 4 5.

R	Engineering Metrology by I.C.Gupta / Dhanpat Rai Publishers.
R	Precision Engineering in Manufacturing by R.L.Murthy / New Age.
R	Engineering Metrology and Measurements by NV Raghavendra, L Krishna murthy, Oxford publishers.
R	Engineering Metrology by KL Narayana, Scitech publishers
T	Measurement Systems: Applications & design by D.S Kumar.
R	Mechanical Measurements / BeckWith, Marangoni,Linehard, PHI / PE.
R	Measurement systems: Application and design, Doeblin Earnest. O. Adaptation by Manik and Dhanesh/ TMH.
R	Experimental Methods for Engineers / Holman
T	Mechanical and Industrial Measurements / R.K. Jain/ Khanna Publishers
R	Instrumentation, measurement & analysis by B.C.Nakra & K.K.Choudhary, TMH.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
R13214	Engineering Physics Lab	Screw gauge and vernier caliper	I-II
R13216	Workshop Technology Lab	Deals With initial use of vernier calipers marking gauges and few types of calipers and dial gauges	I-II

COURSE OBJECTIVES:

1	The Metrology Laboratory course is designed for measuring and inspection of precision linear, geometric forms, angular and surface finish measurements
2	The student can learn the measurements with and calibration of instruments. They also understand the machine tool alignment test.
3	Calibration of various instruments for measuring pressure, temperature, displacement, speed, vibration etc.

COURSE OUTCOMES:

SNO	DESCRIPTION	PO (1..12) MAPPING	PSO (1..3) MAPPING
1	Apply measurement techniques using Vernier calipers, micrometers, and dial bore indicators, and analyze straightness and flatness of surfaces for precision. (L3 - Apply)--------CO1	PO1, PO4, PO7, PO12	PSO1,PSO2
2	Compare the measurement techniques for determining lengths, heights, and diameters using vernier calipers and micrometers to assess dimensional accuracy. (L4 - Analyze)--- CO2	PO1,PO2,PO4, PO7,PO12	PSO1,PSO2
3	Analyze thread profiles and assess surface roughness using precision measuring instruments for quality evaluation.—CO3	PO1, PO4	PSO2
4	Apply calibration techniques for pressure gauges, LVDT transducers, and strain gauges to ensure accurate measurements in engineering applications. (L3 - Apply)CO4	PO5	PSO1

5	Evaluate The calibration techniques for speed, temperature, and capacitive transducers to ensure accurate measurements.(L4 - Analyze) CO5		
COURSE OVERALL PO/PSO MAPPING: PO1, PO2,PO4, PO5, PO7, PO12,PSO1, PSO2			

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

SNO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
206.1	1			3			1			2	3	2	3	2
206.2	1	2		3			1					2	3	2
206.3	2			2										1
206.4					1								1	
206.5	2	2		3	1		1					2	3	2

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop and implement sustainable mechanical and environmental systems
PO2	Problem Analysis	PO8	Ethics	PSO2	Quality in national and international competitive examinations for successful higher studies and employment
PO3	Design & Development	PO9	Individual & Team Work		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Life Long Learning		

COs VS POs MAPPING JUSTIFICATION:

SNO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
R20MEC-PC3206.1	PO1	1	Basic understanding of length, height, and diameter measurement techniques using Vernier calipers, micrometers, and bore gauges contributes to fundamental engineering knowledge.
	PO4	3	Conducting precision measurements requires investigative skills and attention to detail in experimental procedures.
	PO6	1	Ensuring measurement accuracy is essential for maintaining safety and quality in manufacturing.
	PO10	2	Proper documentation of measurement results enhances technical communication skills.
	PO11	3	Performing accurate measurements supports cost-effective manufacturing and quality control.
	PO12	2	Learning and applying various measurement techniques fosters continuous professional development in engineering metrology.
R20MEC-PC3206.2	PO1	1	Understanding the use of precision instruments like dial bore indicators and gear tooth vernier calipers supports basic engineering knowledge.

	PO2	2	Analyzing measurement deviations and interpreting results involves problem-solving skills.
	PO4	3	Hands-on experience with different measuring instruments develops investigative and analytical skills.
	PO6	1	Measurement accuracy ensures reliability in mechanical and manufacturing applications.
	PO10	2	Effective recording and reporting of measurement findings improve technical communication.
	PO11	3	Accurate measurements directly impact quality control and cost efficiency in engineering applications.
	PO12	2	Familiarity with different measuring tools is essential for lifelong learning and industry adaptability.
R20MEC-PC3206.3	PO1	2	Performing machine tool alignment tests requires fundamental mechanical engineering knowledge.
	PO4	2	Investigating machine tool errors and assessing alignment develops research-based problem-solving skills.
	PO12	1	Understanding machine alignment principles helps in professional development and maintenance practices.
R20MEC-PC3206.4	PO4	1	Performing basic angle and taper measurements contributes to investigative skills.
	PO12	1	Learning about different measurement techniques contributes to ongoing engineering education.
R20MEC-PC3206.5	PO1	2	Understanding calibration principles for pressure gauges, transducers, and other instruments strengthens engineering fundamentals.
	PO2	2	Analyzing calibration data helps develop problem-solving skills.
	PO4	3	Conducting calibration experiments enhances investigative and analytical capabilities.
	PO5	1	Hands-on experience with calibration equipment involves modern engineering tools.
	PO6	1	Proper calibration ensures safety and reliability in engineering applications.
	PO10	2	Documenting calibration results strengthens technical reporting and presentation skills.
	PO11	3	Understanding calibration principles is essential for cost-effective maintenance and process optimization.
	PO12	2	Mastery of instrumentation and calibration supports continuous learning in engineering applications.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS, POs & PSOs:

SNO	DESCRIPTION	PROPOSED ACTIONS
1	Coordinate Measuring Machine	Explanation given with videos
2	Autocollimator	Explanation given with videos
3	Comparator	Explanation given with videos
4	Measurement of Density & Viscosity	Explanation given with videos
5	Quantity Meters, Area Flow Meters and Mass Flow Meters	Explanation given with videos

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

1	Co ordinate Measuring Machine
2	Autocollimator
3	Radiations Sources
4	Lasers Classification, Lasers Applications.

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=oJFUI_FHlio
2	https://www.youtube.com/watch?v=i_p0jzB-8pE
3	https://www.youtube.com/watch?v=tMkXC4vl89Y
4	http://nptel.ac.in/courses/103105064/41
5	http://nptel.ac.in/courses/103105064/35

DELIVERY/INSTRUCTIONAL METHODOLOGIES/PEDAGOGICAL INITIATIVES:

☐CHALK & TALK	☐STUD. ASSIGNMENT	☑WEB RESOURCES	☐NPTEL/OTHERS
☐LCD/SMART BOARDS	☐STUD. SEMINARS	☐ ADD-ON COURSES	☐ WEBNIARS

ASSESSMENT METHODOLOGIES-DIRECT:

☐ASSIGNMENTS	☐ STUD. SEMINARS	☐ TESTS/MODEL EXAMS	☐UNIV. EXAMINATION
☑ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT:

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

(HOD)

Signature of the PAC Member

Metrology Lab

EXPERIMENT NO: 1

MEASUREMENT OF LENGTH, HEIGHT AND DIAMETER BY VERNIER CALIPERS,VERNIER HEIGHT GAUGE AND MICROMETER

AIM:

To measure the length, height, and diameter of a given work piece by using vernier calipers, micrometer and vernier height gauge respectively and to find error in instruments by using slip gauges (calibration)

APPARATUS: -

Vernier calipers, micrometer, Vernier height gauge, surface plate, slip gauges.

THEORY:

1. *Vernier calipers:*

The principle of Vernier caliper is that when two scales (or) divisions slightly differ in size are used. The difference between them can be utilized to enhance the accuracy of measurement. The Vernier calipers essentially consists of two steel rules and these can slide each other in one of the scale **v**, main scale is engraved on a solid **L**- shaped frame, parts so that one small division equals 0.05 cm. One end of the frame consists of a fixed screw which is shaped into a contact tip at its extensity. Basically Vernier calipers consists of three parts (v) beam, fixed jaw, sliding Jaw. These three permit substantial improvements in the commonly used measuring techniques ones direct measurement with graduated lines. The movable jaw achieves positive contact with the graduated lens.

The movable jaw achieves positive contact with the object boundary at the opposite end of the object. The sliding jaw at its left extensity contains another measuring tip when the two measuring tip surfaces in contact with each other scale shows reading zero. These calipers are classified into three types. These are type A, type B type C. Type ‘A’ has jaw on both sides for external and internal measurements and also has a blade for depth measurement. Type ‘B’ is provided jaws on one side for external and internal measurements. Type ‘C’ has jaws on both sides for making the measurements and for marking operations. Errors are usually made while viewing the measurements with vernier calipers. For manipulation of measurement of vernier calipers and its jaws on the work piece. The measurement of error for a given work piece can be detected in the carrying procedure.

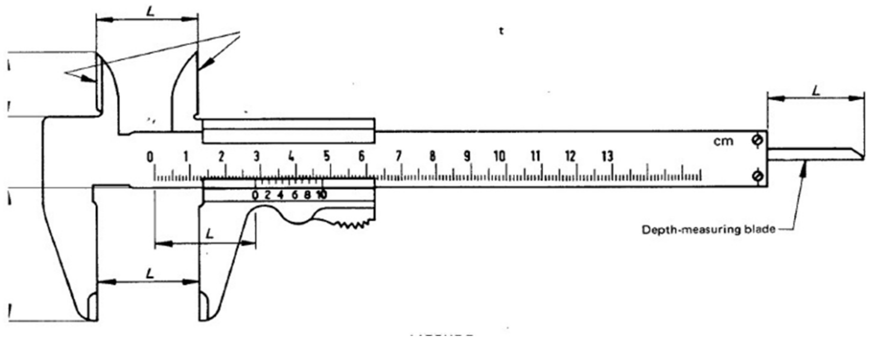


Fig: 1.Vernier calipers

2. *Micrometer:*

The micrometer screw gauge essentially consists of an accurate screw having about 10 (or) 20 threads ‘1’ cm and revolves in a fixed nut. The end of the screw forms one measuring tip and other measuring tip is constituted with a stationary arrival in the base of the frame. The screw is threaded for certain length and in plain afterwards. The plain portion is called sleeve and its end is measuring surface. The spindle is advanced or retracted by turning a thimble connected to the spindle. The spindle is a slide fit over the barrel and barrel is fixed part attached with the frame. The barrel is graduated in unit of 0.05 cm i.e. 20 divisions/cm, which is the lead of the screw. For one complete revolution the thimble is got 25 divisions over around is periphery on circular position.

Thus it sub divider each revolution of the screw in 25 equal parts i.e. each division corresponds to 0.002 cm. A lock nut is provide for locking a dimension by preventing the motion of spindle. Ratchet screw is provided at the end of the thimble cap to maintain sufficient and uniform measuring pressure that standard conditions of measurement are attained. Ratchet stop consists of an overriding clutch held by a weak spring. When the spindle is brought into contact with the work at the correct measuring pressure, the clutch starts slipping and no further movement of spindle takes place by the notation of ratchet, in the back word movement it is positive due to shape of ratchet.

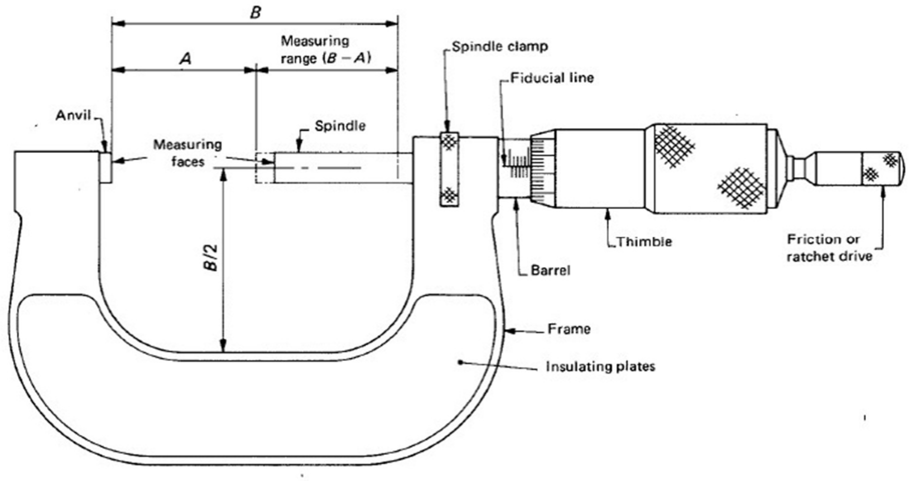


Fig 2: Micrometer

3. Vernier height gauge:

This is also sort of Vernier caliper equipped with a special base block and the other attachments. Along with the sliding jaw assembly arrangement is to carry a removable clamp. The upper and lower surfaces of measuring jaws are parallel to the base so that it can be used for measurement ones or under a surfaces. The Vernier height gauge is mainly used in the inspection of the path and layout work, with scribing attachments in place of measuring jaw. This can be used to scribe the lines at certain distance above the surface. However the dial indicators can also be attached in the clamp and many useful measurements made as it exactly gives the indicator when the tip is first touching the surface.

For all these measurements, the use of surface plates as bottom surface is very essential. The basic parts of height gauge are base, beam measuring jaw and scriber. Graduations and slides precautions are to be taken when the height gauges are not generally in use.

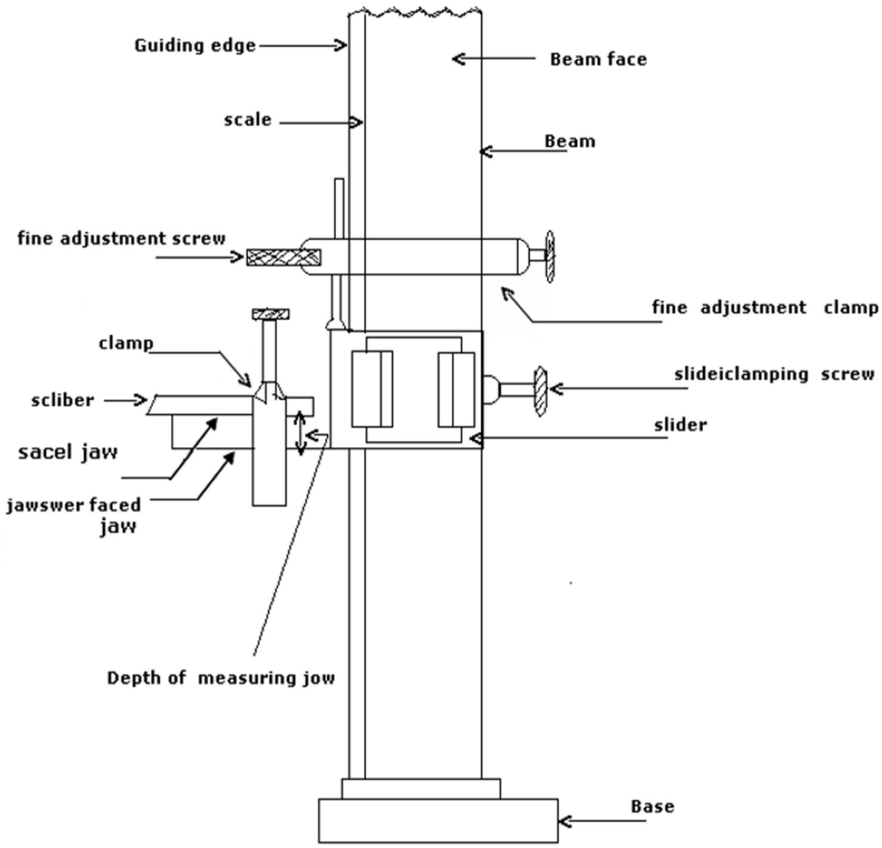


Fig 3: Vernier height Guage

PROCEDURE:

1. In the measurement of length of a work piece, it is kept first in a vernier caliper and then the movable jaw is moved so that the fixed jaw and movable jaw holds the work piece. Then tighten the screws for a perfect fit between the jaws.
2. Then note the reading on the main scale and on vernier scale so that length of exact work piece is obtained.
3. Now the slip gauges are arranged to obtain length and thus slip gauges are measured with vernier calipers.
4. If the instrument shows the same reading, then there is no error in the instrument. If it is not, then record the error in measurement.
5. Similarly in the height measurement of a work piece also first height of the work piece is measured with vernier height gauge and the slip gauges are arranged to obtain height. Now these slip gauges are measured by height gauge. If there is any error then it is recorded.
6. Similarly in the case of diameter measurement of work piece first diameter of work piece is measured using micrometer and the slip gauges are measured by micrometer. If there is any

error then it is recorded.

OBSERVATIONS:

Vernier calipers And Vernier Height Guage:-Least count = 0.02 mm

S.No	SPECIMEN	Main scale Reading M.S.R(mm)	Vernier scale Reading V.S.R(mm)	Total reading M.S.R+V.S.R*L.C	READING USING DIGITAL VERNIER CALLIPERS	Error
1						
2						
3						

Micro meter:

Least count = 0.01mm

S.No	SPECIMEN	Main scale Reading M.S.R(mm)	Vernier scale Reading V.S.R(mm)	Total reading M.S.R+V.S.R*L.C	READING USING DIGITAL MICROMETER	Error
1						
2						
3						

PRECAUTIONS:

1. The work piece should not be clamped in the caliper jaws and waved in air.

2 .No play should be there between the sliding jaw and scale, otherwise the accuracy is lost.

3 .Vernier calipers must always be held at short leg of main scale, and jaws never pulled.

RESULT:

The height of job by V.C and V.H.G …………

The height of job by Micrometer ………….

The inner diameter of job by V.C ……………

The height of job by Micrometer …………….

The outer diameter of job by V.C …………

EXPERIMENT NO: 2

MEASUREMENT OF BORES USING DIAL BORE INDICATOR

AIM: To find the internal diameter of hole by using vernier calipers,inside micrometer and checking the same by using dial gauge indicator.

APPARATUS:-

Work piece, vernier caliper and dial gauge indicator set with anvil.

THEORY:

Dial gauge indicator:

These are the instruments designed for checking bore diameter by the comparative method. The instruments principle of operation is shown in figure. The instrument basically consists of a hallow tube into which is contained a lever pivoted about one end of the lever is linked to the movable contact of the instrument i.e the instrument has three contacts. Equally spaced along the circumference of the head. One being movable above and two fixed ones and other end of the lever actuates the pointer. The three contacts bears against the internal surface of the rest and properly the instrument in relation to the axis of the bore being checked. The contacts are interchangeable with roads in order to broaden the range of measurement, the smallest size. This instrument can check in the order of 1.8 — 3.4 cm in diameter. The range of setting in about ± 0.06 to ± 0.22 cm with scale division value of 0.002 and 0.01 respectively.

PROCEDURE:

First of all take the work piece where internal diameter is to be calculated.

1. Now take the vernier calipers and place the knife edges inside the work piece and read the reading for internal diameter of work piece.
2. See the reading that is obtained from micrometer. If the reading is say 34.8 mm then take the anvil of size 34 mm and washers of size 0.5 mm and fit it to the body of the gauge.
3. Now set the dial gauge indicator for zero position and then make readings at any position inside the work piece. This should be done carefully as the anvil movable screw will wear in rough handling of the gauge.

4. The above step is repeated for different positions inside the work piece.
5. Now set micrometer to 34.8 mm and kept this micrometer to dial gauge indicator and note down the reading.
6. Now calculate the internal diameter using given formulae
7. Actual size = anvil length + washer length ± (R1 R2) x m . R1= reading obtained in dial gauge when the same dial gauge kept in micrometer. R2= reading obtained from the work piece.

OBSERVATIONS:

Rough measurement of bore using A — type

Micrometer: Least count of micrometer =0.01 mm

S.NO.		Micrometer calipers reading		
	Name of the specimen	Main scale reading (M.S.R) (mm)	Reading on the thimble (T.R)(mm)	Total reading M.S.R+(T.R*L.C)mm
1	B2			
2	B2			
3	B2			

∴ *Average reading = 25.23mm*

Accurate measuring using dial bore indicator

S.NO.	Name of the specimen	Bore gauge reading (R_1)	Work piece reading (R_2)	Final reading (R2-R1)
1	B2			
2	B2			
3	B2			

Accurate interna1 diameter of hole using dial bore indicator ....

RESULT :-

Internal diameter of the work piece by using MICROMETER is **………..**

Diameter obtained by using dial gauge indicator is **……………**

EXPEIMENT NO: 3

ANGLE AND TAPER MEASUREMENT USING BEVEL PROTRACTOR AND SINE BAR

AIM: To measure the taper angle of the given work piece using bevel protractor and sine bar.

APPARATUS:- Sine bar, slip gauges, bevel protractor, magnetic stand and dial indicator.

THEORY:

Bevel Protractor: It is the simplest instrument for measuring the angle between the two faces of a component. It has the following ports.

Body: It is designed in such a way that its back is flat and there are no projections beyond its back so that when the bevel protractor is placed on its back on a surface plate, there shall be no perceptible rock.

Blade:- It can be moved along the turret through out its length and can also be reversed, it is about 150 or 300 mm. long, 13 mm wide ad 2 mm thick and ends beveled at an angle of 1D to 60° with an accuracy of 5 of arc. It s working edge should be straight up to 0.02 mm and parallel up to 0.03 mm over the entire length of 300 mm.

Scale on the body: The body contains a main scale engraved on it and which can be locked in any position. An adjustable blade which is attached to a circular plate containing vernier scale. The vernier scale has 24 divisions coinciding with 23 main scale divisions. Thus the least count of the instrument is 5 . The main scale is graduated either as a full circle marked 0°— 90° - 0° 90° with a vernier.

Slip gauges :

These are ultimate measuring tool for checking dimensions in mechanical engineering. These are rectangular blocks of hardened steel with two parallel and opposing surface. The distance between the surfaces determines the nominal size. The echon of a slip gauge is 9 x 30 mm for nominal size up to 10 mm, sine bar.- sine bar used in conjunction with slip gauges constitute a very good device for measurement of angles. Two cylinders of equal diameter are attached at the each other and at equal distance from the upper surface of the sine bar. The distance between the axis of cylinder is 200 mm. sine bars are made from high carbon, high chromium, corrosion resistant steel.

PROCEDURE:

Procedure for using bevel protractor to measure angles:

The given component is so adjusted in between the base plate and the adjustable blade such that no gap should exists between them. After the adjustment, the scale is locked in that position in order to avoid errors in measuring the angle. Read and note the angle included in between the faces of the component.

Procedure for using sine bar to measure and check taper

The length in between two markings on the face of the given component is measured. Using the angle obtained in measurement by bevel protractor and distance between the sine bar rollers (200 mm), the height of slip gauges is calculated. Now sine bar is placed on the surface plate and the component is placed on the sine bar such that the midpoint of the component should coincide with the mid position of sine bar.

Slip gauges are placed below the roller to raise the smallest height of the component. A magnetic stand with dial indicator is used to check the flatness of the component.The surface of the component and the surface plate is mutually parallel to each other. If any deviations is observed in the dial indicator, then there is an error in angle. Otherwise the measured angle is accurately and it is the angle of tapered face of the given component.

PRECAUTIONS:-

1. To avoid the error in measuring angle, the adjustable blade is to be locked at required positions.
2. The parallax error is to be avoided in reading and noting valued through bevel protractor.
3. The given component should be placed at the middle of the sine bar to avoid errors in taper measurement.

OBSERVATIONS:

Measurement of angle using bevel protractor:-

Least count = $\mathbf{5^1}$

	Angle Of Bevel Edge		
S.NO.	M.S.D	V.S.D	Total reading [M.S.D+(V.S.D]
1			

Calculations:

RESULT: -

The angle of the workpiece using bevel protractor is $\mathbf{7^0.5^1}$ and by using sinebar set combination is $\mathbf{7^0 8^1}$

EXPERIMENT NO: 4

MEASUREMENT OF THICKNESS OF GEAR TOOTH BY VERNIER TOOTH CALIPER

AIM: To measure the thickness of gear tooth by using vernier tooth caliper.

APPARATUS:

Gear tooth vernier caliper, spur Gear

THEORY:

The tolerance on the thickness of the tooth is the variation as actual thickness of tooth from its theoretical value. The tooth thickness is generally measured at pitch circle and is called pitch line thickness at the tooth. Thickness measured along the arc of the pitch circle is called circular pitch which is difficult to measure. It is sufficient to measure the chordal thickness in most of the cases (the chord joining the intersection as the tooth profile with the pitch circle is chordal thickness). Since the difference between the chordal thickness and the circular thickness being very small for gears of small pitch.

The thickness measurement is most important measurement which is most of all the measurements out of all measurements of various method available for measurement of the tooth thickness by gear tooth verifier is in expensive and very simple due to the capacity of the instrument is to measure the thickness at the desired position as the thickness of the teeth varies from the tip to the root and this alignment is achieved by two vernier scales fixed in perpendicular direction one to measure depth(d) and other to measure the thickness simultaneously.

For in volute teeth as shown in figure:

Circular tooth thickness = AEB

Chord thickness = ADB

N = ADB = 2AD

Now $\angle AOD = \theta = \frac{3w}{4T}$

T → No. of Teeth

But w = 2AD = 2x OA sin a

$= 2 \text{ R} \sin \left(\frac{360}{4T} \right)$

Where m → module and d= mT

d = OC—OD

OC =OE+ addendalum = R + m = $\frac{mT}{2}$ + m

OD=OA cos θ

$d = m\left(\frac{T}{2} + 1 \right) - R\cos\left(\frac{360}{4T} \right)$

$$\text{Chord addendum} = \frac{mT}{2}\left[1 + \frac{2}{T} - \cos\left(\frac{360}{4T} \right) \right]$$

PROCEDURE :

1. First we calculate the chordal thickness and chordal addendum theoretically by given in mathematical relation.
2. By fixing chordal addendum on the vertical scale of the gear tooth Vernier caliper.
3. Then calculate the thickness the tooth by horizontal scale of gear tooth Vernier
4. The experimental value and theoretical value is compared. If any error is observed it is noted.
5. The above procedure is repeated for different teeth.

OBSERVATIONS:

Error is vertical scale of gear tooth vernier calipers = **0.31**

(1) Module of gear wheel, m **1.81**

No. of teeth on gear wheel = T= **32**

Theoretical chordal addendum = $\dfrac{mT}{2}\left[1+\dfrac{2}{T}-\cos\left(\dfrac{360}{4T}\right)\right]$

= **1.867mm** (2)

The vertical scale is set at [(1) + (2)] =**2.841mm** ∵ (1) = error correction

∵ (2) addendum height

Theoretical chordal thickness = m T sin $\left(\dfrac{360}{4T}\right)$

S.No.	Theoretical Tooth thickness (mm)	Actual tooth thickness			Error
		M.SR (mm)	V.S.R	Total Reading [M.S.R+(V.S.R ×L.C)]	
1					
2					

PRECAUTIONS:

1. Accuracy in measurement is limited by the coast count the instrument.
2. Need different settings for variation in number of fore given pitch.
3. As the user, during use is concentrated on both the jaws, the calipers has to be calibrated at regular intervals.

RESULT :

Actual chordal tooth thickness by using 'Gear'

EXPERIMENT NO: 5

SURFACE ROUGHNESS MEASUREMENT BY TALY SURF

AIM:

To measure the surface roughness using taly surf instrument.

APPARATUS:-

Taly surf, work piece, surface plate.

THEORY:

Tally surf is an electronic instrument working on carrier modulating principle. This instrument gives the information rapidly and accurately. This instrument is also as the previous one record the static displacement of the system and is dynamic instrument like profilometer.

The measuring head of this instrument consists of a diamond stylus of about 0.002 mm tip radius and skid as shoe which is drawn across the surface by means of motorized driving unit, which provides three speeds giving 20 x 20 horizontal magnifications and a speed suitable for average reading. A neutral portion in which pivots about E — shaped stamping. There are '2' resistances from an oscillator. As the armature is pivoted about central leg. Any movement of the original AC current flowing the coils is modulated. The output of the bridge thus consists of modulation . This is further demodulated so that the current flow is directly proportional to the vertical displacement of the stylus only.

The demodulated output is caused to operate a pen recorder to produce a permanent record and the meter to give a numerical assessment directly. In recorder of this instrument the making medium is a electrical discharge, there is a specially treated paper which blanks at the point of the stylus. So this has no distortion due to drag and stylus. So this has the records strictly rectilinear one.

PROCEDURE:-

1. The power supply to the tally surf measuring instrument is given and it is checked with the reference sample for current roughness
2. The instrument is bound on the specimen properly and then the measurement is stored by pressing start/stop button. Note down Ra & R_z values using parameter button.
3. Repeat the experiment on specimen by changing the distribution.
4. Repeat the above process for the remaining specimen and tabulate the readings.

OBSERVATIONS:

S.No	Measurement roughness value m Sample, direction R_a R_z 4 R_q	Average R_a	Average R_q	Average R_z	Grade
1	Specimen-1				
2	Specimen-1				
3	Specimen-1				

RESULT:

Surface roughness using taly surf instrument is measured

EXPERIMENT NO: 6

FLATNESS OF SURFACE PLATE BY USING SPIRIT LEVEL

AIM:

To determine the flatness of surface plate by using spirit level.

APPARATUS:

Surface plate, Spirit level

THEORY:

The spirit of level consists of a sealed glass tube mounted on a base. The inside surface of the tube is ground to a convex barrel shape having large radius. The precision of the level depends on the accuracy of this radius of the tube. A scale is engraved on the top of the glass tube. The tube is nearly filled with either ether or alcohol, except a small air or vapor in the form of a bubble.

The bubble always tries to remain at the highest point of the tube. If the base of the spirit level is horizontal, the centre point is the highest point of the tube. So, that when the level is placed on a horizontal surface, the bubble rests at the centre of the scale. If the base of the level is fitted through a small angle, the bubble will more relative to the tube a distance along its radius corresponding to the angle.

Surface Plate spirit level

The figure shows two positions of the base of the level(OA_1 and OA_2) and corresponding positions of the bubble (Bl,B2). When the base OA_1 is horizontal, the bubble occupies position B_1. Let ‘ θ ‘ be the small angle through which the base is fitted. The bubble now occupies the position B2.Let L be the distance travelled by bubble along the tube and ‘h’ the difference in heights between the ends of the base. Then L= Rθ and h =. Lθ

Therefore $\theta = \frac{l}{\mathbf{R}} = \frac{h}{\mathbf{L}}$

$$\therefore l = h\frac{R}{\mathbf{L}}$$

Where R = radius of curvature of the

tube L = length of base

Finally h = $\frac{\mathbf{L}}{\mathbf{R}}$

PROCEDURE:

1. Place the spirit level on the surface plate for which we have to find out the flatness
2. Find the base length of the spirit level
3. Note the radius of curvature of the spirit level tube
4. Find the tilt in the bubble
5. Finally find out the difference in heights between the ends of the base
6. With the help of spanner adjust the four sides of the surface plate
7. Adjustment are to be made till the bubble on x and y direction come to the middle of the surface sprit level

PRECAUTIONS:

1. Clean the surface plate and ensure there is no dust particles
2. Take the bubble reading without any parallax error.
3. Do not lean or put ur hands on the surface plate which may cause disturbance

RESULT:

The surface plate is checked for flatness with the bubble in the middle with respect to X and Y Direction

EXPERIMENT NO:7

MEASUREMENT OF SCREW THREAD BY TOOL MAKER'S MICROSCOPE

AIM:

To study the gear tooth nomenclature, rake angle**.**

APPARATUS: -

Tool maker's microscope, gear wheel cutting tool.

DESCRIPTION:

Tool maker's microscope consists of optical head which can be adjusted vertically along the ways of a supporting column. The optical head can be clamped in any position by a screw. The working table is inserted on a heavy hollow base. The table has a compound slide by means of which the measured part can have longitudinal and lateral movements. These movements are controlled by accurate micrometer screws having thimble scales and vernier. At the back of the base is arranged a light source which provides a horizontal beam of light which is reflected from a mirror but go upwards towards the table. A shadow image of the outline of contour of the part passes through the objective of optical head and is projected by a system of three prisms. Cross lines are engraved on the ground glass screen which can be rotated through 360° and the measurements are made by these cross lines.

PROCEDURE:

1. The illuminating lamps are switched on the required intensity.
2. The following length of the microscope is adjusted to get a clear view of the tool under the observation.
3. Through the micrometers adjustment / the depth and thickness of gear are calculated by placing the line of the eyepiece parallel to the edge of the shank.
4. The angle of cutting tool is measured through the adjustment of inclined lines with the edges of the tool bit and subsequent measurement through the circular scales provided, either at the eyepieces or at the work table.

5. Thus the measurements are completed using the tool maker's microscope.

OBSERVATIONS:

S.No	Description	Initial reading R1 mm	Final reading R2 mm	Actual reading $R_1 \sim R_2$
1	Overall length of the screw			
2	pitch			
3	Major diameter			
4	Minor diameter			

S.No	Angle of the helix	Angle in degrees	
		Initial	Final
1.			
2			

PRECAUTIONS:

1 The microscope should not be disturbed with the experiment has been completed.

2 Readings should be taken without parallax error.

RESULT:-

Gear tooth nomenclature is thus studied.

EXPERIMENT NO:8

MEASUREMENT OF CENTRAL DISTANCE BETWEEN TWO HOLES

AIM: To measure the central distance between the two holes of the template using vernier height gauge.

MEASURING INSTRUMENTS & TOOLS:

Vernier
height gauge
Surface plate
Angle plate with
clamps Bevel protractor

THEORY: Vernier height gauge will be used to measure and mark vertical distances above a reference surface with the help of knife edge or lever type dial indicator fitted to the measuring jaw. With this capability the utility of vernier height gauge can be extended to measure the central distance between the two holes of a template. The template should have two adjacent sides corrected to right angle accurately, which will be the reference sides.

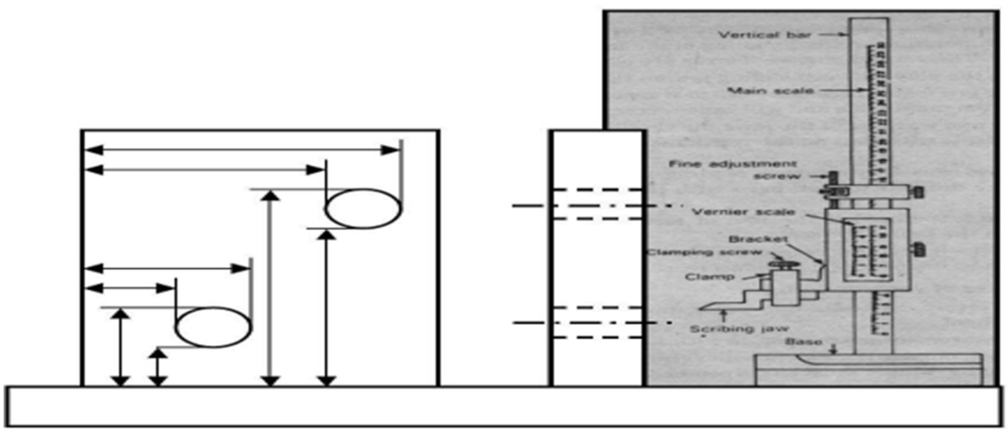


Figure 4: Vernier Height Gauge

PROCEDURE:

1. The template sides were checked for 90° angle using a bevel protractor.
2. Any two sides at right angle were selected and the template was fixed to the angle plate so that one of the sides under consideration touching the surface plate.
3. The heights of the lowest and highest points of the two holes under consideration were found using vernier height gauge with reference to the surface plate.
4. The procedure was repeated and the heights of the same holes were measured with reference to the second side of the template.
5. All the readings were tabulated and central distance between the two holes was found by finding the coordinates of the same holes.

PRECAUTIONS:

1. Vernier height gauge should be set to read zero on the surface plate.

2. The template should be clamped properly to angle plate to ensure the plan of the plate perpendicular to the surface plate.
3. Care should be taken while seeing the coincidence of the knife edge with the edges of the holes.

OBSERVATIONS:

L.C of the vernier height gauge =0.02

REFERENCE SIDES OF TEMPLATE

s.no	Reference side	x_1 (mm)	x_2 (mm)	x_3 (mm)	x_4 (mm)	X_1 (mm)	X_2 (mm)	y_1 (mm)	y_2 (mm)	y_3 (mm)	y_4 (mm)	Y_1 (mm)	Y_2 (mm)
1	left												

Calculations:

Result: Measurement of Central Distance Between Two Holes by measuring with vernier height gauge = 110.41

Instrumentation Lab

Experiment No:- 1

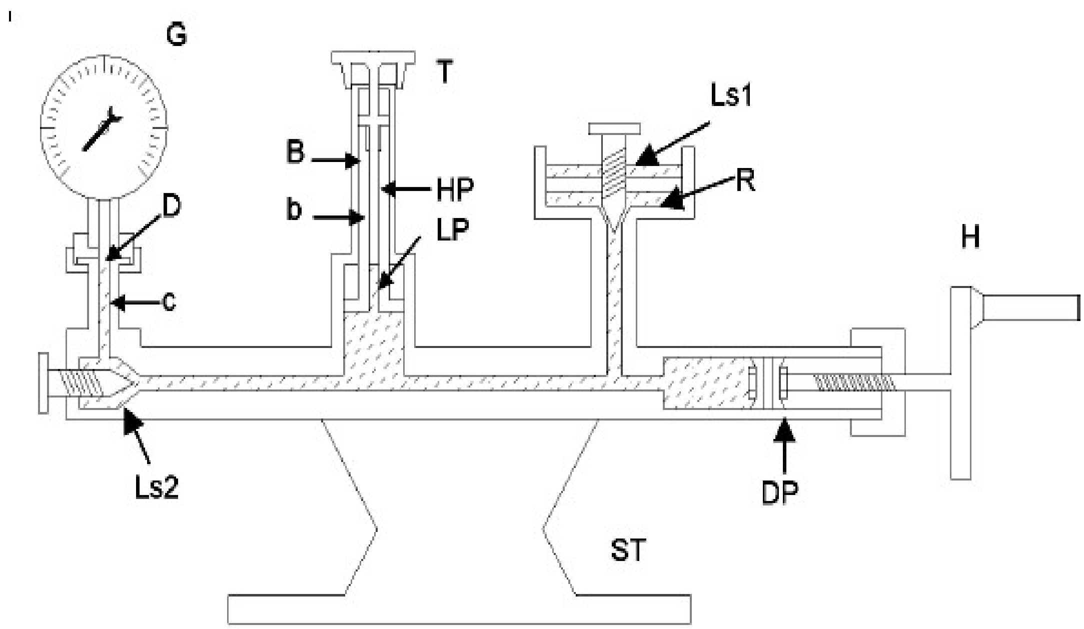
CALIBRATION OF PRESSURE GAUGES

Aim: To calibrate pressure gauge by using dead weight pressure gauge tester

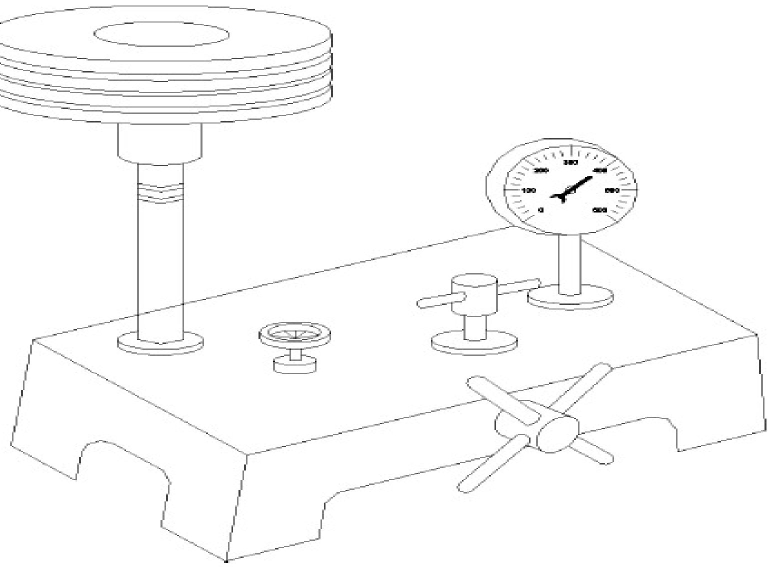
Apparatus: Bourdon gauge, dead weight tester.

Theory:

Pressure gauge, especially Bourdon's gauge is calibrated by means of dead weight tester.The essential components of such a tester is reservoir 'R', cylinder 'C', barrel 'B' and passage up to'C' to hold up clean dry oil. A spindle 'S' with highly finished surface and precise cross-sectionalarea slides vertically in the barrel 'B' through close fitting, highly polished bearing 'b' and carries thetable 'T' at its upper end. Its lower end rests on 'HP' piston.Screws 'Ls1' and 'Ls2' lock the passage of oil when required. The tester is mounted on a stand 'ST'.It is provided with special precise weights marked in terms of pressure. A double piston 'DP' can bemoved forward and backward by rotating the handle 'H'.



Constructional set up



Dead weight tester and Bourdon tube pressure gauge

The double acting piston works both ways and does not allow the oil to leak. The gauge under calibration can be connected at ‘D’ such that the connection is leak tight. With ‘Ls1’ and ‘Ls2’ open, the handle is rotated such that the oil is just in level with the gauge connecting points ‘D’, and ‘Ls2’ is now locked. The gauge ‘G’ is mounted carefully. ‘H’ is rotated until the table ‘T’ is at raised position in line with the upper edge of colour band. ‘Ls1’ is then locked. ‘Ls2’ is opened and the handle H is rotated such that the gauge needle just moves and reads some minimum pressure characteristics of the tester because of the weight of the unloaded table acting through the piston’ LP’. A weight is placed on the table increasing the pressure on the oil in the tester.

SPECIFICATIONS
DEAD WEIGHT PRESSURE GAUGE TESTER

CAPACITY: 50 Kg/cm2 AREA : 0.196 Cm2

DEAD WEIGHTS : 1Kg -2Nos.,2 Kg – 1No.,5 Kg -3Nos,10Kg-3No’s., PLUNGER

WEIGHT : 1 Kg

ACCURACY : 0.5%

LINEARITY : 0.5%

MAX. OVER LOAD : 150 %

TEST GAUGE : 56 Kg/cm2 Bourdon Pressure gauge

<u>The Dead weight pressure gauge tester comprises of the following</u>:

Hydraulic Pump: The pump fitted is of Single Cylinder reciprocating type oil pump

Oil Reservoir: Acrylic tank with metal cover to store oil to build the pressure.

Piston : Piston to load the dead weight. It is of 5mm diameter shaft. So the pressure builtcan be calculated as fallows.

$$P = \frac{W}{A}$$

Where P is pressure built due to weight Kg / cm^2 W is the weight in Kg and A is the area of the piston in cm^2

Speciman calculation : Weight required for 1 Kg/cm^2

$$\text{Area of the piston} = \frac{\pi \times D^2}{4}$$

D = diameter of the piston = 0.5 cms

$$A = \frac{\pi \times 0.5^2}{4} = 0.196 \text{ cm}^2$$

$$\text{So} \quad \text{Weight} = \frac{0.196}{1} = 0.196 \text{ Kg} = 196 \text{ Grams.}$$

So the Dead weight required to build 1 Kg/cm^2 Pressure is 196 Grams.

1/8" BSP Port: Pressure Port to connect Test gauge to the deadweight tester.

Control valve: Stainless steel Needle valve to control the pressure and to release the pressure.

Operating Procedure

1. Fill the Oil tank with sufficient Oil. **(Hydraulic oil SERVO/CASTROL 40 grade)**
2. Release the AIR RELEASE VALVE provided at the bottom till the oil starts drippingContinuously about 10 to 12 drops and tighter the release valve.
3. Release the control valve and pump the oil so that the oil circulates through the tubes. Pump for a wile about a minute so that all the tubes will be filled with oil and any air bubble inside the tube will be removed.
4. Now close the Control valve, and Pump the oil the plunger starts floating. Rotate the plungergently. The plunger should rotate smoothly without any friction pump a

little if the plunger is not rotating smoothly. The pressure is built inside the chamber proportion to the weight on theplunger. The Test Gauge fixeSd will starts showing the pressure.

5. Add 1 Kg dead weight on the plunger and pump once again till the mark on the plunger isvisible. The pressure inside the chamber increases by 1Kg/cm^2.
6. Add the weights on the plunger and pump till the line on the plunger is clearly visible.
7. The bourdon pressure gauge will read the pressure corresponding to the dead weights on theplunger. Note down the readings on the pressure gauge and tabulate the readings with thecorresponding readings to the dead weight.
8. Plot the graphs for actual pressure (dead weightsv/s pressure gauge reading. Calculate the accuracy, linearity and hysteresis of the pressuregauge.
9. Release the control valve slowly and remove the dead weights from the plunger.

Precautions:

1. Rotate the plunger along with the weights while taking the readings.
2. Maintain sufficient quantity of oil in the oil tank.
3. Do not pump when the AIR RELEASE VALVE IS loosened.

Tabular column:

1. S.NO.	2 LOAD APPLIED (ATA)	3 ACTUALPRESSURE IN KG/CM^2	4 INDICATING READING IN KG/CM^2	5 DEVIATION (3 – 4)
1				
2				
3				
4				
5				

$$\% \text{ Linearity} = \frac{\text{Max error} \times 100}{\text{max. pressure}}$$

To calculate Linearity: Plat the graph for actual Pressure V/s Test gauge. Max. % error is the linearity of the Test gauge.

Graph: actual Pressure V/s Test gauge pressure

Result: calibrated pressure gauge by using dead weight pressure gauge tester

Experiment no: 2

CALIBRATION OF RESISTANCE TEMPERATURE DETECTOR FOR TEMPERATURE MEASUREMENT

AIM: To calibrate the given RTD by using Thermometer

APPARATUS: Temperature sensor (RTD), Heating coil to heat water in water bath, Digital temperature Indicator & Thermometer. **THEORY**:

RESISTANCE TEMPERATURE DETECTORS (RTDs)

The change in the resistance of metals with temperature provides the basis for family of temperature measuring sensors known as resistance temperature detectors. The sensor issimply a conductor fabricated either as a wire wound coil or as a film or foil grid. The change inresistance of the conductor with temperature is given by the expression,

$$\Delta R / R_o = \lambda_1(T-T_o) + \lambda_2 (T- T_o)^2 + \ldots\ldots + \lambda_n (T- To)^n$$

Where T_o is a reference temperature .

R_0 is the resistance at temperature T_o

λ_1 , λ_2 , ... λ_n are temperature co-efficient of resistance.
Platinum is widely used for sensor fabrication since it is the most stable of all the metals, is the leastsensitive to contamination, and is capable of operating over a very wide range of temperatures. Thedynamic response of on RTD depends almost entirely on construction details.Resistance thermometers, also called **resistance temperature detectors or resistive thermal devices (RTD)**, are temperature sensors that exploit the predictable change in electrical resistance of some materials with changing temperature. As they are almost invariably made of platinum, they are often called **platinum resistance thermometers (PTR)**. They are slowly replacing the use of thermocouples in many industrial applications below 600oC, due to higher accuracy and repeatability. There are many categories like carbon resistors, film and wire wound types are the most widely used.

Carbon resistors are widely available and are very inexpensive. They have very reproducible results at low temperatures. They are the most reliable from at extremely low temperatures. They generally do not suffer from significant hysteresis or strain gauge effects.

Film thermometer have a layer of platinum on a substrate, the layer may be extremely thin, perhaps one micrometer. Advantage of this type is relatively low cost and fast response. Such devices have improved performance although the different expansion rates of the substrate and platinum give “strain gauge” effects and stability problems.

Wire – wound thermometers can have greater accuracy, especially for wide temperature ranges. ***Coil element**s have* largely replaced wire wound elements in industry. This design has a wire coil which can expand freely over temperature, held in place by some mechanical support which lets the coil keep its shape.

SPECIFICATION

SENSOR : RTD

DISPLAY : 31/2 Digit LED Display. 200mV FSD to read upto +/-1999 count INITIAL &FINAL SET : Through single turn Potentiometer.

TEMPERATURE : 1000 C

TEMP. SOURCE : Water kettle.

TEMP. MASTER : Glass bead Thermometer.

PANEL DETAILS

DISPLAY : 31/2 Digit LED Display of 200 mV FSD

INITIAL SET : Single turn potentiometer to set Initial Temperature(Room temperature)

FINAL SET : Single turn potentiometer to Calibrate the instrument(Max. temperature)

POWER ON : Rocker switch to control power supply to the instrument.

OPERATING PROCEDURE

1. Check connection made and Switch ON the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON Position for 10 minuets for initial warm-up.
3. Pore around 3/4th full of water to the kettle and place sensors and thermometer inside the kettle
4. Note down the Initial water temperature from the thermometer.
5. Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.
6. Switch on the kettle and wait till the water boils note down the reading in the thermometer and set Final set potentiometer till the display reads boiling water temperature.
7. Remove the sensor from the boiling water immerse it in the cold water. Set the cold water temperature using initial set potentiometer.

8. Repeat the process till the display reads exact boiling water and cold-water temperature.Change the water in the kettle with and re heat the water. Now the display startsshowing exact temperature raises in the kettle.
9. Note down the readings for every 100 C rise in temperature. and tabulate the readings inthe tabular column for Indicator reading and thermometer reading.

Experiment to measure temperature using RTD sensors.

Experiments can be conducted on the instrument as per the operating instruction given above andvarious parameters like Linearity, Accuracy, Hysteresis etc. can be calculated. The readings can be tabulated and graphs can be plotted to calculate the above parameters.

Tabular Column:

1 S NO.	2 THERMOMETER REAEING ^{O}C (Actual Temperature)	3 INDICATOR READINGRTD ^{O}C	4 ERROR
1			
2			
3			
4			
5			

Graphs: Actual reading V/s indicator Reading

Result: -Thus RTD were calibrated using digital thermometer

Experiment no: 3

CALIBRATION OF THERMISTER TEMPERATURE MEASUREMENT

AIM: To calibrate the given Thermister by using Thermometer

APPARATUS: Temperature sensor (Thermister), Heating coil to heat water in water bath, Digital temperature Indicator & Thermometer

THEORY:

A Thermister is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a portmanteau of thermal and resistor. Thermister are widely used as inrush current limiters, temperature sensor, self-resetting over current protectors and self-regulating heating elements. Thermister differ from resistance temperature detectors (RTD) in that the material used in a Thermister is generally a ceramic or polymer, while RTD's use pure metals. The temperature response is also different, RDT's are useful over larger temperature ranges, while Thermister typically achieve a higher precision within a limited temperature range (usually – 90 oC to 130 oC).

Assuming, as a first order approximation, that the relationship between and temperature is linear, then

$\Delta R = k\ \Delta T$ Where,

ΔR = change in resistance ΔT =

change in temperature

k = first order temperature co-efficient of resistance

Thermister can be classified into two types, depending on the sign of k. if k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature co- efficient (PTC) Thermister or posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature co-efficient (NTC) thermistor. Resistors that are not thermistor are designed to have a k as close to zero as possible, so that their resistance remains nearly constant over a wide temperature range.

SPECIFICATION

SENSOR	:	thermister
DISPLAY	:	31/2 Digit LED Display. 200mV FSD to read upto +/-

1999 count

INITIAL & FINAL SET : Through single turn Potentiometer.

TEMPERATURE : 1000 C

TEMP. SOURCE : Water kettle.

TEMP. MASTER : Glass bead Thermometer.

PANEL DETAILS

DISPLAY : 31/2 Digit LED Display of 200 mV FSD

INITIAL SET : Single turn potentiometer to set Initial Temperature(Room temperature)

FINAL SET : Single turn potentiometer to Calibrate the instrument (Max. temperature) POWER ON : Rocker switch to control power supply to the instrument.

CONNECTION DETAILS

POWER : 3 pin mains cable is provided with the instrument. Connect the 3 pin socketto the instrument at the rear panel and to the AC mains 230v supply.: Connect the kettle to 230 V supply with the cable supplied.

SENSORS : Connect RTD to the connector on the rear panel.

ADVANTAGES:

- High accuracy
- Low drift
- Wide operating range
- Suitable for precision applications.

PROCEDURE:

1. Turn the selector switch to the desire position according to the given sensor probe (Thermister / RTD).
2. Connect the given sensor to the temperature display unit.
3. Place the sensor probe and the thermometer into a beaker containing water at room temperature.
4. Connect the power supply to the temperature indicator.
5. Record the room temperature from the thermometer.
6. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.

7. Connect the power supply to hearting coil and heat the water in the bath.

8. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX Knob.

9. Now the given thermocouple is calibrated with reference to thermometer

10. Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals

OBSERVATION AND TABULAR COLUMN

1 **S NO.**	**2** **THERMOMETER REAEING^{O}C** **(Actual Temperature)**	**3** **INDICATOR READING THERMISTER** **^{O}C**	**4** **ERROR** **%**
1			
2			
3			
4			
5			

GRAPHES: Actual Temperature V/S Indicating Temperature

RESULT: Thus the Temperature of Thermister were calibrated using digital thermometer

Experiment No: 4

CALIBRATION OF THERMOCOUPLE FOR TEMPERATURE MEASUREMENT

Aim:To calibrate the given thermocouple using thermometer

APPARATUS: Thermocouple,

A heating coil to heat the water in the water bath,

Thermometer and a digital indicator to indicate the temperature of thermocouple.

THEORY:

The common electrical method of temperature measurement uses the thermocouple, when two dissimilar metal wires are joined at both ends, an emf will exist between the two junctions, if the two junctions are at different temperatures. This phenomenon is called Setback effect. If the temperature of one junction is known then the temperature of the other junction may be easily calculated using the thermoelectric properties of the materials. The known temperature is called reference temperature and is usually the temperature of ice. Potential (emf) is also obtained if a temperature gradient along the metal wires. This is called Thomson effect and is generally neglected in the temperature measuring process. If two materials are connected to an external circuit in such a way that current is drawn, an emf will be produced. This is called as Peltier effect. In temperature measurement, setback emf is of prime concern since it is dependent on junction temperature.

The thermocouple material must be homogeneous. A list of common Thermocouple materials in decreasing order of emf chrome, iron and copper platinum – 10% rhodium, platinum, alumel and constantan (60% copper and
40% nickel). Each material is thermoelectrically positive with respect to the
below it and negatives with respect those above. The material used in the Thermocouple probe is:

1. Iron – Constantan (Type J)
2. Copper – Constantan (Type T)
3. Chromyl – Alumel (Type K)

SETUP:

Setup comprises of thermometer as a reference and three types of Thermocouples as mentioned above, to be calibrated. The entire sensor can be placed in a hot bath where the water can be heated up to boiling temperature through heating coil. Heater of capacity 500 watts is provided which will be connected to the 230V, 50Hz. power supply through three-pin mains cord.

DIGITAL TEMPERATURE INDICATOR:

Temperature indicators for thermocouples are provided in a unit with digital display. For thermocouples, the output of the sensor (i.e. in mV) is amplified through electronic circuits. Calibration provision is provided out to calibrate any sensor required. RTD sensor is calibrated and the output in terms temperature in degree centigrade is displayed.

PANAL DETAILS:

POWER ON: Rocker switch which switches on the supply of the instrument, with red light indication.

MIN: Single turn potentiometer. The display can be adjusted to read minimum temperature, when no voltage output from the sensor is measured.

MAX: Single turn potentiometer. The output of the amplifier is adjusted by this potsuch that the display reads same as in the given reference temperature. i.e. Thermometer temperature reading.

SELECTOR: Two-position selector switches to select Temperature or mV output of the sensor.

SELECTOR: Three- position selector switches to select J-type / K-type / T-type thermocouples.

TERMINALS: Screw type terminals are provided to connect the given thermocouples.

MAINS SUPPLY: Power cable. Power cable to be connected to the mains supply of230V, 50Hz.

FUSE: 500 mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

CAUTION: Do not remove the fuse cap with power cable plugged to the mains supply.

C I R C U I T E X P L A N A T I O N

The circuit comprises of three parts :

1. POWER SUPPLY
2. SIGNAL CONDITIONING AND AMPLIFYING
3. ANALOG TO DIGITAL CONVERTER

1. **POWER SUPPLY:**

Inbuilt power supply use power to all electronic devices inside the circuitry. High stable regulated Power supply is used for better performance. There are two different power supply inside the unit. +5

- 0 - -5 V 5000mA for Analog and Digital circuits and also for sensor excitation

2. **SIGNAL CONDITIONING AND AMPLIFYING.**

The circuitry comprises of signal conditioner and amplifier. The output of the sensor is amplified to required level. The Thermocouple gives out directly which is amplified. Thermistor and RTD are connected to the ground through a resister, and the voltage is applied to the other end of the sensor.

The resistance change in the sensor will gives the mV out put which is amplified and controlled. Analog out put is fad to the ADC.

3. **ANALOG TO DIGITAL CONVERTER.**

The output from the amplifier is a linearised analog DC voltage. This analog output isconverted into digital output with the help of IC 7107 3.5 digit 200mA A to D converter. Thenit is displayed through seven segmented LEDs.

SPECIFICATION

SENSOR : J- type Thermocouple (Fe-K)

DISPLAY : 31/2 Digit LED Display. 200mV FSD to read upto +/-1999 count INITIAL &FINAL SET :Through single turn Potentiometer.

TEMPERATURE : 1000 C

TEMP. SOURCE : Water kettle.

TEMP. MASTER : Glass bead Thermometer.

PANEL DETAILS

DISPLAY :31/2 Digit LED Display of 200 mV FSD

INITIAL SET : Single turn potentiometer to set Initial Temperature (Room Temperature) FINAL SET : Single turn potentiometer to Calibrate the instrument (Max. Temperature) POWER ON : Rocker switch to control power supply to the instrument.

CONNECTION DETAILS

POWER : 3 pin mains cable is provided with the instrument. Connect the 3 pin socket to the instrument at the rear panel and to the AC mains 230v supply. Connect the kettle to 230 V supply with the cable supplied.

SENSORS : Connect Thermocouple to the connector on the rear panel.

PROCEDURE:

1. Turn the type selector to the desire position according to the given T.C probe.

2. Connect the given thermocouple to the temperature display unit.
3. Place the thermocouple and the thermometer into a beaker containing water at room temperature.
4. Connect the power supply to the temperature indicator.
5. Record the room temperature from the thermometer.
6. Adjust the MIN setting knob of the temperature indicator until the display shows the room temperature.
7. Connect the power supply to hearting coil and heat the water in the bath.
8. Set the temperature of thermocouple to the thermometer reading when the water is boiling, using MAX knob.
9. Now the given thermocouple is calibrated with reference to thermometer.

Record the thermometer reading and the temperature indicator reading simultaneously at regular intervals.

OBSERVATION AND TABULAR COLUMN

Material for thermocouple wires = IRON

Sl. no	**Temp. of Water by Thermometer, Ta oC**	**Temp. of Water by Thermocouple, Tm oC**	**Error Tm - Ta**	**% Error (Tm - Ta) / Tm**
1				
2				
3				

Material for thermocouple wires = COPPER

Sl. no	**Temp. of Water by Thermometer, Ta ^oC**	**Temp. of Water by Thermocouple, Tm ^oC**	**Error Tm - Ta**	**% Error (Tm - Ta) / Tm**
1				
2				
3				

Material for thermocouple wires = CHROMYL

Sl. no	**Temp. of Water by Thermometer, Ta oC**	**Temp. of Water by Thermocouple, Tm oC**	**Error Tm - Ta**	**% Error (Tm - Ta) / Tm**
1				
2				
3				

GRAPHS: Draw the following graphs: Thermometer Reading Vs J,K and T-type Thermocouple Reading

RESULT: Thus the Temperature of Thermo couples were calibrated using digital thermometer

Experiment No:- 5

CALIBRATION OF LVDT TRANSDUCER FOR DISPLACEMENT

Aim: To determine the characteristics of LVDT (linear variable differential transformer).

Apparatus required: LVDT, Digital displacement indicator, calibration jig (micrometer).

Theory:

Differential transformers, based on a variable Inductance principle, are also used to measuredisplacement. The most popular variable-inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT). The LVDT illustrated in the fig. consists of three symmetrically spaced coils wound onto an insulated bobbin. A magnetic core, which moves through thee bobbin without contact, provides a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the center or primary coil and with the two outside or secondary coils. When an AC carrier excitation is applied to the primary coil, voltages are induced in the two secondary coils that are wires in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induces between the secondary coils are equal but out of phase by 1800. The voltage in the two coils cancels and the output voltage will be zero. When the core is moves from the center position, an imbalance in mutual inductance between the primary coil and the secondary coil occurs and an output voltage develops. The output voltage is a linear function of the core position as long as the motion of the core is within the operating range of the LVDT.

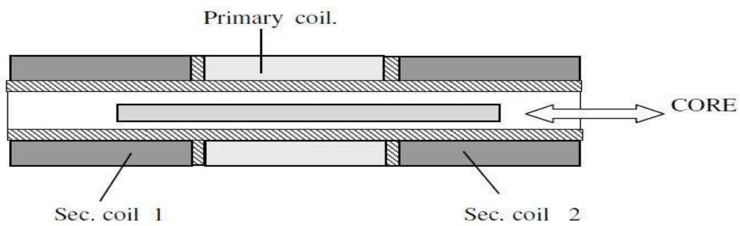
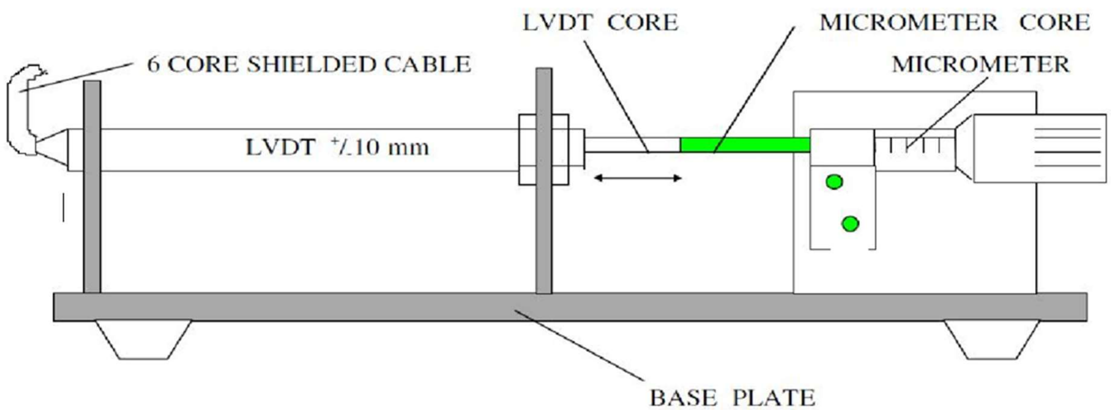
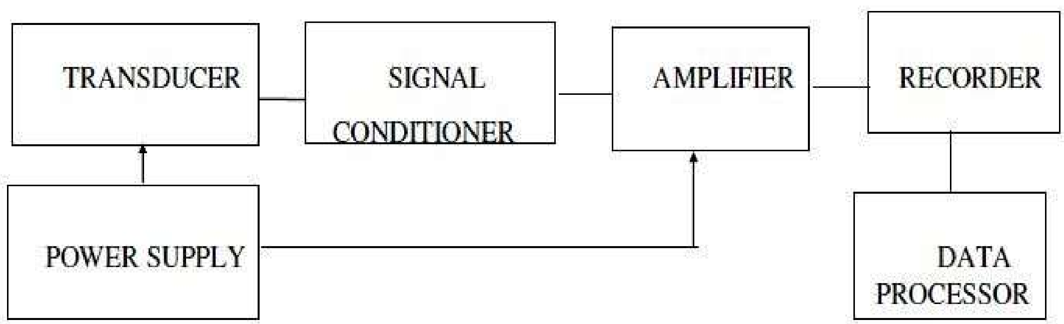


Diagram to shows schematically the working of LVDT.



THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.The **TRANSDUCER** is a devise that convert a change in the mechanical or thermal quantity beingmeasured into a change of an electrical quantity. Example strain gauges bonded in to an specimen,gives out electrical output by changing its resistance when material is strained



.

The **POWER SUPPLY** provides the energy to drive the Transducers, example differentialtransformer, which is a transducer used to measure displacement requires an AC voltage supply toexcite the coil.

SIGNAL CONDITIONERS are electronic circuits that convert, compensate, or manipulate the output from in to a more usable electronic quantity. Example the whetstone bridge used in the straintransducer converts the change in resistance DR to a change in the resistance DE

AMPLIFIERS are required in the system when the voltage out put from the transducer signalconditioner combination is small. Amplifiers with gains of 10 to 1000 are used to increase theirsignals to levels where they are compatible with the voltage - measuring devices.

RECORDERS are voltage measuring devices that are used to display the measurement in a formthat can be read and interpreted. Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the out put signals from the instrument system intodata that can be easily interpreted by the Engineer . Data processors are usually employed wherelarge amount of data are being collected and manual reduction of these data would be too timeconsuming and costly.

SPECIFICATION INDICATOR

* Display:31/2 digit seven segment red LED display of range200mV for full scale deflection. to read +/- 1999counts.
* Excitation Voltage:1000 Hz at 1V
* Operating Temperature: +100 C to 550 C
* Zero Adjustment:Front panel through Potentiometer.
* Sensitivity: 0.1mm
* System Inaccuracy: 1%
* Repeatability: 1%
* Connection: Through 6 core shielded cable with Din connector.
* Fuse: 250mA fast glow type.
* Power: 230 V +/- 10 %, 50 Hz.

SENSOR

* Range: +/- 10.0 mm
* Excitation Voltage: 1 to 4 kHz at 1 to 4V
* Linearity: 1%
* Operating Temperature: +100 C to 550 C
* Connection: Through 6 core shielded cable provided along with thesensor of 2M length.
* Calibration Jig: Micrometer of 0 to 25mm length is mounted on the base.

Procedure:

1. Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on theinstrument By pressing down the toggle switch. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON position for 10 minutes for initial warm-up.
3. Rotate the micrometer till it reads “20.0”

4. Adjust the CAL potentiometer at the front panel so that the display reads “10.0”

5. Rotate the core of micrometer till the micrometer reads “10.0” and adjust the ZERO potentiometer till the display reads “00.0”

5 Rotate back the micrometer core upto 20.0 and adjust once again CAL Potentiometer till the displayread

10.0. Now the instrument is calibrated for +/-10.0mm range. As the core of LVDT moves the display reads the displacement in mm.

6. Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT.

7. Tabulate the readings and Plot the graph Actual V/s indicator reading.

EXPERIMENT & TABULAR COLUMN

Measurement of displacement through LVDT is well accepted method in process control instrumentation. In measurement Repeatability, Linearity, Accuracy is important factors. So the experiment to test the LVDT for all these factors. Experiment is the Known displacement is given to the LVDT core through micrometer and the displacement sensed by the micrometer can be noted down. Graph of Micrometer reading versus LVDT reading can be Plotted. Accuracy and the linearity of the LVDT can be calculated by thegraphs. Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating thereadings both for ascending and descending of displacement.

TABULAR COLUMN

S.NO	**Input Displacement In mm (+Ve)**	**Meter displacement in mm (+ve)**	**Input Displacement In mm (-Ve)**	**Meter displacement in mm (+ve)**
1				
2				
3				
4				
5				

Precautions:

1. Initial zero setting may done properly
2. Move the core gently
3. While taking readings parallax error has to avoid.

Model graph: Micrometer reading Vs Indicated reading

Result: Thus the displacement is calibrated by using LVDT

Experiment No:- 6

STUDY AND CALIBRATION OF MCLEOD GAUGE FOR LOW PRESSURE

Aim: Low pressure measurement by McLeod gauge.

Apparatus required: McLeod gauge, Vacuum Cell, Dial type Vacuum gauge Vacuum Chamber, Vacuum pump to develop vacuum and digital vacuum indicator

Theory: In everyday usage, vacuum is a volume of space that is essentially empty of matter, such that its gaseous pressure is much less than atmospheric pressure. The word comes from the Latin for "empty". A perfect vacuum would be one with no particles in it at all, which is impossible to achieve in practice. Physicists often discuss ideal test results that would occur in a perfect vacuum, which they simply call "vacuum" or "free space", and use the term partial vacuum to refer to real vacuum. The Latin term in vacuum is also used to describe an object as being in what would otherwise be a vacuum.

Vacuum is useful in a variety of processes and devices. Its first widespread use was in the incandescent light bulb to protect the filament from chemical degradation. The chemical inertness produced by a vacuum is also useful for electron beam welding, cold welding, vacuum packing and vacuum frying. Ultra-high vacuum is used in the study of atomically clean substrates, as only a very good vacuum preserves atomic-scale clean surfaces for a reasonably long time (on the order of minutes to days).

High to ultra-high vacuum removes the obstruction of air, allowing particle beams to deposit or remove materials without contamination. This is the principle behind chemical vapor deposition, physical vapor deposition, and dry etching which are essential to the fabrication of semi conductors and optical coatings, and to surface science. The reduction of convection provides the thermal insulation of thermos bottles. Deep vacuum lowers the boiling point of liquids and promotes low temperature out gassing which is used in freeze drying, adhesive preparation, distillation, metallurgy, and process purging. The electrical properties of vacuum make electron microscopes and vacuum tubes possible, including cathode ray tubes. The elimination of air friction is useful for flywheel energy storage and ultracentrifuges

Procedure:

1. Connect the tubes (pipes) from vacuum pump to vacuum chamber

and vacuum pump to McLeod gauge.

2. Open the outlet wall before starting the vacuum pump.
3. Close the outlet wall after starting the vacuum pump.
4. Keep the McLeod gauge in horizontal position before starting the vacuum pump.
5. Switch ON the vacuum pump.
6. See the reading in McLeod pump by varying perpendicular axis and note downthe readings.

Tabular column:-

S No	1 Actual Reading in (mm of Hg)	2 Indicator Reading in (mm of Hg)	(1-2) error	3 % error
1				
2				
3				

Graph:- actual reading v/s indicated Digital reading.

Result:- Thus the angular displacement is calibrated by using capacitance transducer

Experiment No:- 7

DIGITAL SPEED MEASUREMENT SYSTEM BY USING PHOTO/MAGNETIC PICKUP

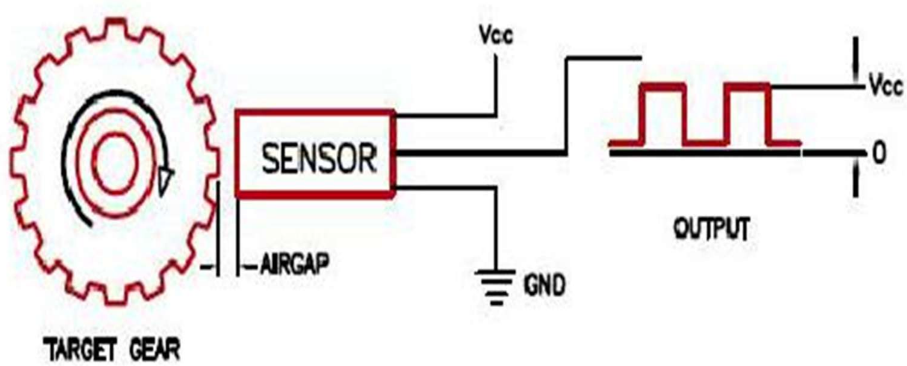
Aim: To measure the speed of the motor by using optical/photo/magnetic proximity sensors

Apparatus required: Digital speed indicator, Optical or photo sensor, Proximity or Magnetic sensor **Theory:**

Digital speed indicator is microprocessor circuit design, accuracy, digital read out. If it is ideal inspecting and measuring the speed of moving gear spans 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 these signals will be input to the indicator and that signal will convert into actual RPM of the motor and indicator will indicate the reading in RPM directly.

Magnetic pickup (Proximity) sensor

It is not contacting sensing device, it sensor to the signal from the rotating body and isvery accurate and very reliable and this sensing device is non contact type and is equal tomagnetic



pick up.

Optical/ photo pickup

It is not contacting sensing device, the lever which is fixed to a rotating shaft from a motor. As the lever rotates with the speed of the shaft, the light passes by the sensor and reflected back by lever is received by sensor in turn producing an output pulse representing logic “1”. These pulses are sent to a register of counter and finally to an output display to show the speed or revolutions of the shaft.

Specifications:

Sensor : magnetic pick up,
photoelectric pick up Max rpm:

1500 rpm
Motor: 5 HP DC motor to rotate at 1500 rpm
Motor speed control: 0 – 12 v variable DC drive Power: the instrument works at 230 v, 50 HZ supply.

Procedure:

1. Switch on the instrument by pushing down the toggle switch provided at the side of the box. Led display glows at to indicate the instrument is on.
2. Allow the instrument for 10 min in on position for initial worm up.
3. Switch on the electronic regulator. The wheel rotates and by selecting the sensor with the help of toggle switch. The display will star indicating exact RPM of the motor.
4. Switch on the instrument and the motor. Then vary the speed of the motor indifferent steps.

Tabular column:

S.No.	Actual speed of motor(rpm) 1 rpm x 150	magnetic sensing pickup device (rpm)	Photo electric pickup (rpm)	Error (m –p)
1				
2				
3				
4				

Graph:-

Result: Thus the speed is calibrated by using photo/optical electric and magnetic pick up sensor

Experiment No:- 8

MEASUREMENT OF ANGULAR DISPLACEMENT USING CAPACITIVE TRANSDUCER

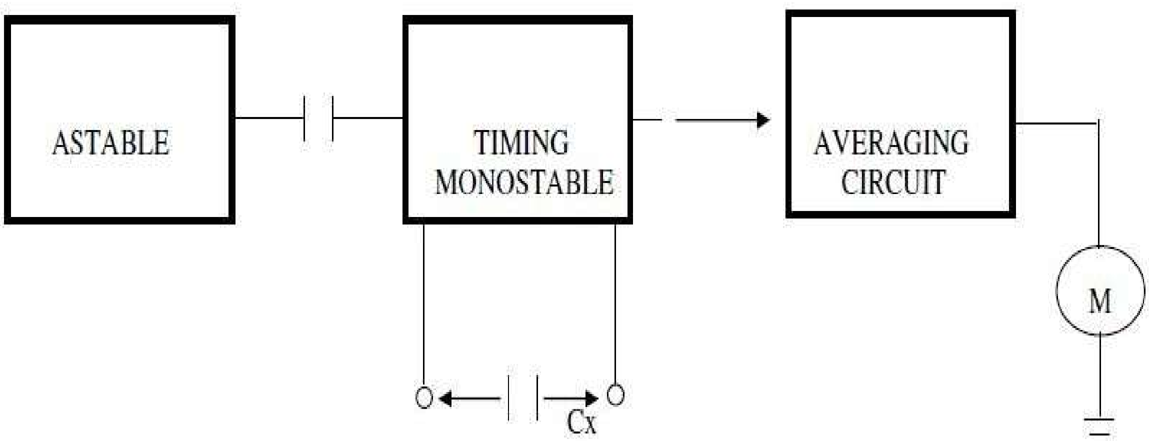
Aim: Measurement of angular displacement using capacitive transducer

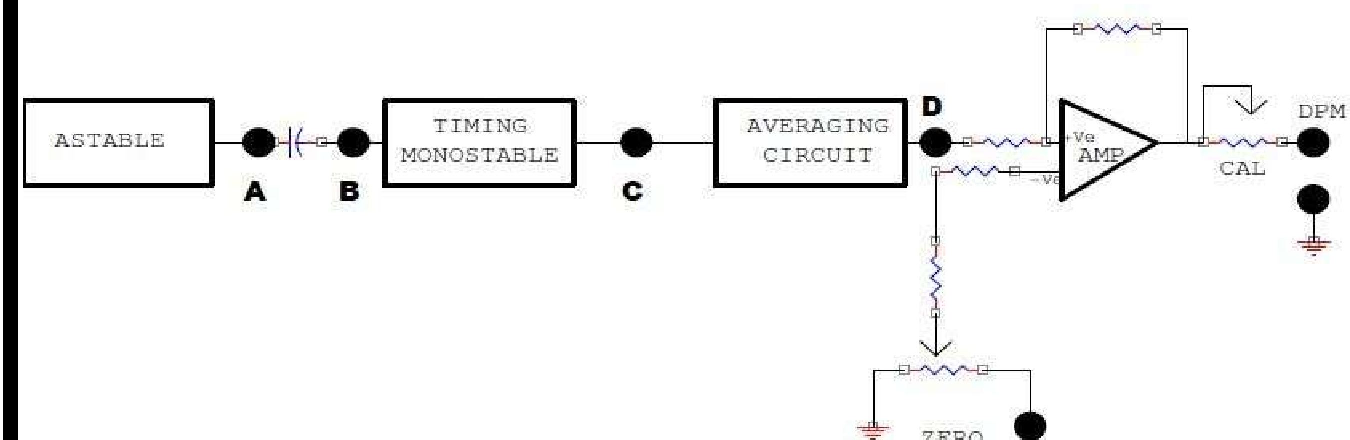
Apparatus required: Capacitive transducer & Angular displacement indicator

Theory:

Unique Capacitance trainer Module is the best trainer to demonstrate the use of capacitance as a transducer. Two plates (A1), one fixed to the base and the other moving over the fixed plate parallel with a small gap between the two. The over lapping of the plate will act as a capacitor with air as dielectric media. The parallel plate capacitor is used as a displacement sensor, which measure the displacement. The other Capacitance transducer is used for measurement of angular displacement. Gang condenser is used to measure the angular displacement. Here the thin aluminum plates are fixed to one pole between these plate thin aluminum plates of same dimension overlap as the other pole on which the plates are mounted. This will induce the capacitance between the plates which varies based on the area of overlapping of the plates.

BLOCK DIAGRAM OF ELECTRONIC CAPACITANCE METER





S P E C I F I C A T I O N

1. Sensor : Angular Plate capacitance. Sensor Material : Aluminum plates Dielectric Medium : Air
2. Displacement : 0-900

Accuracy : 5 to 10%

Display : 3.5 digit LED display to read +/- 1999 counts for+/- 200 mv FSD Power : 230V +/- 10% 50 HZ

Operating Procedure

a. Check connection made to the instrument
b. Allow the instrument in ON position for 10 minutes for initial warm-up.
c. Move the moving plate to Zero position.
d. Adjust the ZERO potentiometer so that the display reads '000'.
e. Move the plate in step of 5 to 10 mm (or 100 for angular sensor) and note down the reading in the tabular column till 50 mm (900).

Experiment and Tabular Column

Measurement of displacement using capacitance is a demo model to demonstrate the use of capacitance as displacement sensor. In measurement Repeatability, Linearity, Accuracy are important factors. So the experiment is to test the Parallel plate Capacitance for all these factors

EXPERIMENT

Known displacement is given to the Parallel plate and the displacement on the scale can be noted down along with the display readings. Graph of Scale reading versus Display reading can be plotted. Accuracy and the linearity of the Capacitance sensor can be calculated by the graphs.

Repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of displacement can calculate repeatability. The instrument is built around an NE556 integrated circuit. The NE556 is a dual 556 times IC. The first timer is connected as a stable multi vibrator while the second time is used as a mono stable.

Observation table

A S No	B Actual scale readings (deg)	C Indicator readings Capacitance (deg)	D Error (B-C)	E % Error
1				

2				
3				
4				

Graph:- actual scale reading v/s indicator readings capacitance

Result: -Thus the angular displacement is calibrated by using capacitance transducer

Experiment no: 9

CALIBRATION OF STRAIN GAUGE

AIM: To determine the elastic constant (modulus of elasticity) of a cantilever beam subjected to concentrated end load by using strain gauges.

APPARATUS: A cantilever beam with concentrated end load arrangement, Strain gauges and strain indicator

THEORY:

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material get strained. So the material is mechanically strained, this strain is defined as ' The ratio between change in the mechanical property to the original property'. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of ıl So according to the definition strain S is given by

$$S = \Delta l / L \qquad \text{Eq 1}$$

Since the change in the length of the material is very small it is difficult to measure Δl. So the strain is always read in terms of micro strain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material get strained due to load applied, the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored for analysis

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauges is usually expressed in terms of a gauge factor Sg where Sg is given as

$$\Delta R / R = Sg \qquad \text{Eq 2}$$

Where Δ is Strain in the direction of the gauge length.

The output $\Delta R / R$ of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is usedin the other arms, the output voltage is

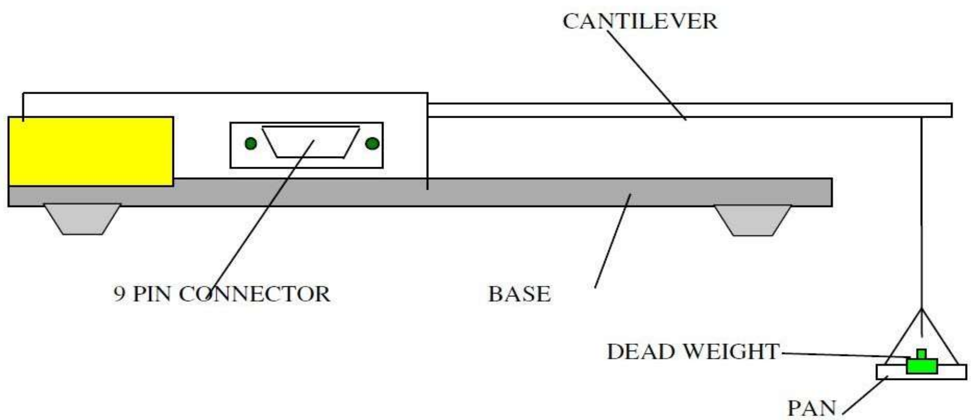
$$Eo = Ei / 4 \, (\Delta Rg / Rg) \qquad \text{Eq 3}$$

Substituting Eq 2 into Eq 3 gives

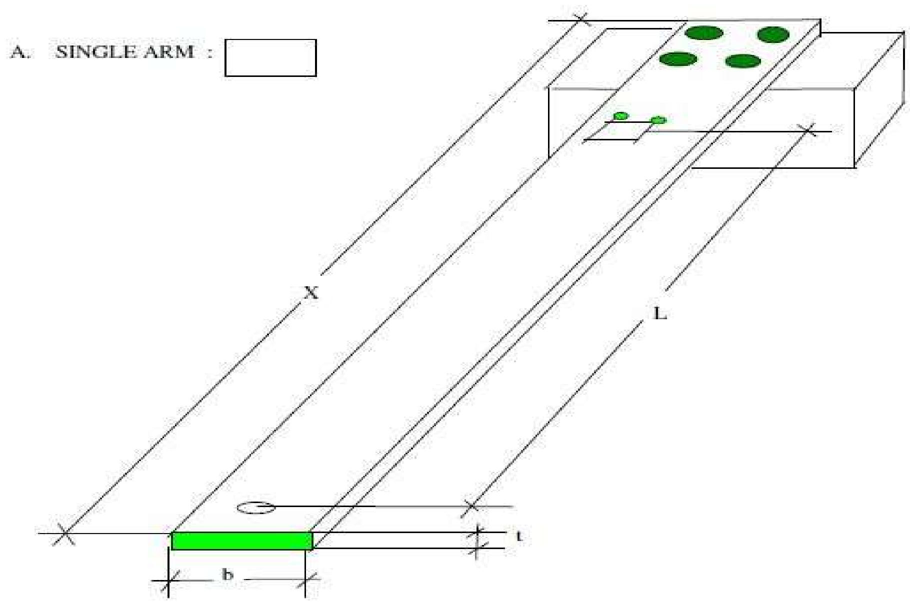
Eo = 1/4 (Ei Sg Δ)   Eq 4

The input voltage is controlled by the gauge size (the power it can dissipate) and the initialresistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 Δ V /microunits of strain.

CANTILEVER BEAM SETUP



PHYSICAL DIMENSION OF THE CANTILEVER BEAM



P H Y S I C A L D I M E N S I O N S

Over all BEAM Length (X) : 300 mm

Actual Length (L) : 220.0 mm (Middle of the Strain Gauge

Grid toloading point) Width of the Beam (b) : 28.0 mm

Thickness of the Beam (t) : 2.5 mm

S P E C I F I C A T I O N

DISPLAY RANGE : 31/2 digit RED LED display of 200 mV FSD to readup to +/- 1999 microstrain . GAUGE FACTOR SETTING : 2.1

BALANCE :Potentiometer to set zero on the panel. BRIDGE EXCITATION : 10V DC

BRIDGE CONFIGURATIONS :

Full Bridge. MAX.

LOAD : 1Kg.

POWER : 230 V +/- 10% at 50Hz. with perfect grounding.

All specifications nominal or typical at 230 C unless noted.

CANTILEVER BEAM SPECIFICATION

MATERIAL : Stainless Steel BEAM THICKNESS (t) : 0.25 Cm. BEAM WIDTH (b) : 2.8 Cms.

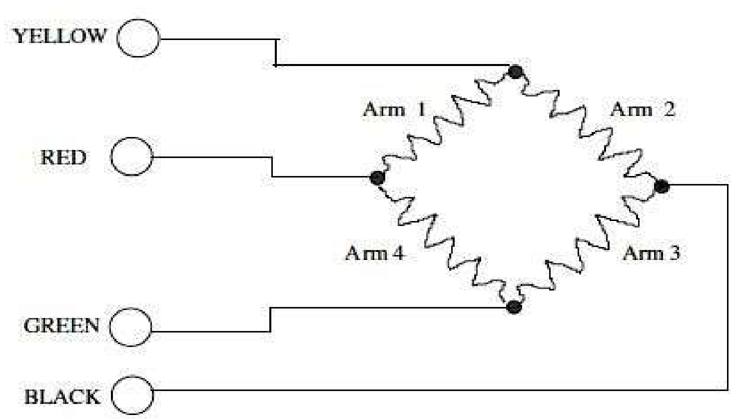
BEAM LENGTH (Actual) : 22 Cms.

YOUNGS MODULUS (□□) : 2 X 10^6 Kg / cm2.

STRAIN GAUGE : Foil type gauge GAUGE LENGTH (l) : 5 mm

GAUGE RESISTANCE (R) : 300 Ohms. GAUGE FACTOR (g) : 2.01

CONNECTION DETAILS



OPERATING PROCEDURE

1. Check connection made and Switch ON the instrument by toggle switch at the back of thebox.
2. The display glows to indicate the instrument is ON.

3. Allow the instrument in ON Position for 10 minuets for initial warm-up.

4. Adjust the ZERO Potentiometer on the panel till the display reads ‘000’.
5. Apply 1 Kg load on the cantilever beam and adjust the CAL potentiometer till the displayreads
6. 377 micro strain. (as per calculations given below) Remove the weights the display should come to ZERO incase of any variation adjust the ZERO pot again and repeat the procedure again. Now
7. The Instrument is calibrated to read micro-strain.
8. Apply load on the sensor using the loading arrangement provided in steps of 100g upto 1Kg.
9. The instrument displays exact microstrain strained by the cantilever beam
10. Note down the readings in the tabular column. Percentage error in the readings, Hysteresis
11. and Accuracy of the instrument can be calculated by comparing with the theoretical values.

Specimen calculation for cantilever beam

S = (6 P L) / BT²E

P = Load applied in Kg. (1 Kg)

L = Effective length of the beam in Cms. (22Cms) B =

Width of the beam (2.8Cms)

T = Thickness of the beam (0.25Cm) E =

Youngs modulus (2×10^6)

S = Microstrain

OBSERVATIOPN TABLE

A S No	B Weight (in grams)	D Indicator readings (grams)	C Actual readings(using formulae) S = (6 P L) / BT^{2}E(in micro strains)		ERROR in %
			Actual	Indicated	
1					
2					
3					
4					
5					

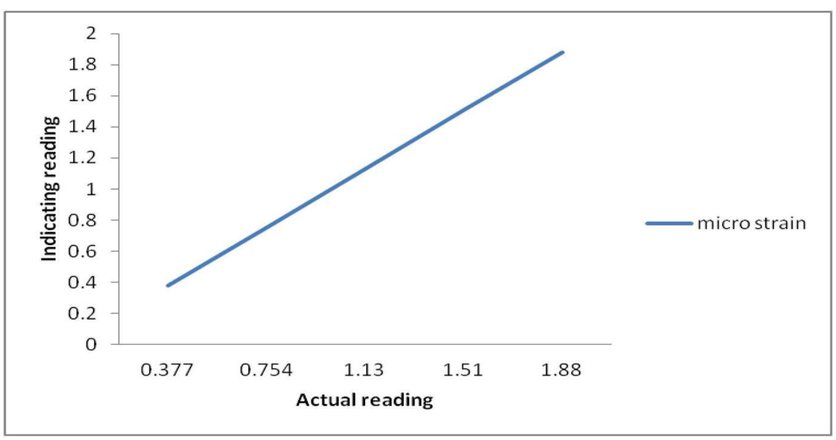
% ERROR = [(Actual Reading (C) - Indicator Readings (D)] x 100

Max. Weight in gms

= ((1.13-1.12)x 100)/500

= 0.000006

Graph: Graph Plotted Actual Readings (X-axis) Vs Indicator Readings (Y-axis)



Result: thus calibrated cantilever beam subjected to concentrated end load by using strain gauges.

Experiment No:- 10

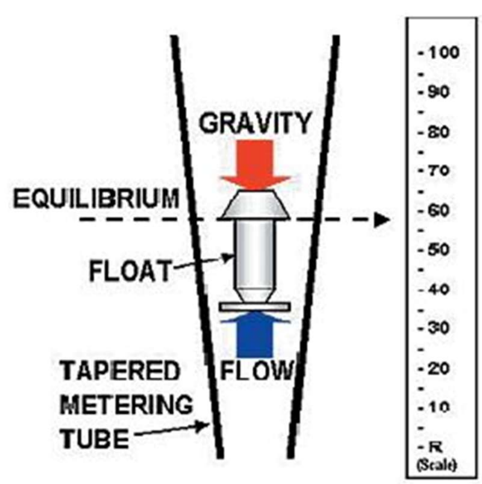
CALIBRATION OF ROTAMETER

AIM: To calibrate the rotameter by using Rotameter experimental setup

Apparatus Required: Rotometer setup, Stop watch,

2lts capacity collecting jar, Control valve, water Circulating system etc., **Theory:**

The rotometerconsists essentially a tapered metering glass tube, inside a float which is located in the Rotameters. The tube is provided with suitable inlet and outlet connecting the float or bob having a specific gravity higher than that of fluid to be metered. In these devices, the falling and rising action of a float in a tapered tube provides a measure of flow rate. Rotameters are known as gravity-type flow meters because they are based on the opposition between the downward force of gravity and the upward force of the flowing fluid. When the flow is constant, the float stays in one position that can be related to the volumetric flow rate. That position is indicated on a graduated scale. Note that to keep the full force of gravity in effect, this dynamic balancing act requires a vertical measuring tube. The tapered tube's gradually increasing diameter provides a related increase in the annular area around the float, and is designed in accordance with the basic equation for volumetric flow rate:



$Q = kA$ x root of g

Where: $\boldsymbol{Q}$ = volumetric flow rate, e.g., Lts per minute

$\boldsymbol{k}$ = a constant

A = annular area between the float and the tube wall

g = force of gravity

h = pressure drop (head) across the float

or

$$Q = C_d\, a_2 \sqrt{2. g. \frac{H(\rho_f - \rho)}{A_f. \rho}}$$

C_d = Coefficient of discharge

Vf = Volume of float

ρf = Density of float

$\rho = Densityoffluid$

$a2 = Annualarareabetweenfloatandtube$

$Af\ . = Maximumcrosssectionalareaof$ the$tube$

Specifications:-

Rotameter : tube type Capacity : 15 to 160 lpm

Source tank : 20 lts approximately Measuring tank: 6 lts

Times: 3 digital times with set point and relay control time set in sec Box dimensions:

250 x 250 x 300 HZ

Power : 230 v , 50 hz

Procedure:

1. Fill the collecting tank with water till ¾ of collecting tank and make sure the pump is immersed in water supply
2. Clear the dust particles if any in water
3. Connect the power supply and switch on the instrument. The timer will on and indicates the previous value. It need alter the set value using increment and decrement keys.
4. Switch on the pump on switch and press the start button set the flow rate 30 LHP using the control knob provided on the rotameter .
5. Set the pressure head by using regulator and adjust the pressure at 1, 2, 3 bars
6. Press the start button on the panel and the times start counting and when it reaches zero the pump is off.
7. Note down the initial water level in cms and final water level in cms for

water rate and tabulate in the tabular column.

Calculations:

Area of collecting tank (A) : $\prod /4 \, x d^2$ d = 150 mm Rise of water in collecting tank ® = mm

Time taken (t) = 60 sec

Actual discharge

$Q_{actual} = (A \times R) / t$

$Q_{theritcal}$ = LPM

(rotameter)

% Error = $(Q_{actual} - Q_{theritcal}) / Q_{actual} \times 100$

TABULAR COLUMN:

S.No	Settime (t) in sec	Rise of Water Level in (t) Sec	Actual flow rate in (lpm) theoretical	Actual low rate in (m^3/sec)	Theoritcal flow rate in (m^3/sec)	%error
1						
2						
3						
`4						

Graph

Result: The given rotameter is been calibrated for the discharge measurement.

Experiment No:- 11

CALIBRATION OF LOAD CELL

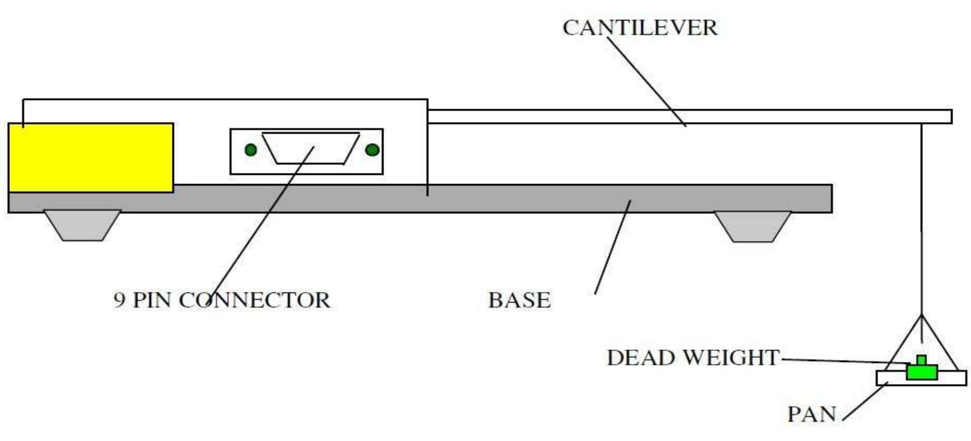
AIM: : To calibrate given load using Wheatstone bridge cell with actual load

APPARATUS: A cantilever beam with concentrated end load arrangement, Load cell of (10 kg capacity), dead weights and digital load indicator.

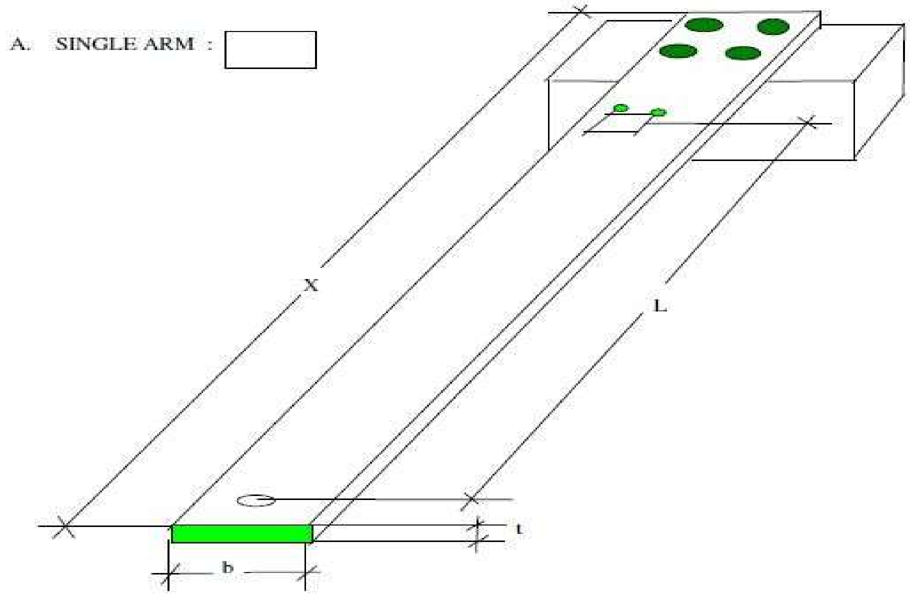
THEORY:

Weighing load/force using spring deflection is widely accepted one. But the deflection of spring reading mechanically is very tedious and time consuming. One of the most effective & accurate method is using strain gauge based load cells. Using the principle of deflection of high tensile strength material when load is applied on it and converting it into proportional electrical signal by using strain gauges will give accurate way of measuring load. **Strain gauge**s are bonded on the columns of corrosion resistance super tough alloy of high tensile strength steel that deforms very minutely under load. This deformation is converted to electrical signal through strain gauges bonded on the column and connected to form a wheat stone bridge. This electrical output is proportional to the load acting on the columns. The output of the load cell is calibrated with reference to some standard i.e., primary standard i.e. dead weights.

CANTILEVER BEAM SETUP



PHYSICAL DIMENSION OF THE CANTILEVER BEAM



P H Y S I C A L D I M E N S I O N S

Over all BEAM Length (X) : 300 mm

Actual Length (L) : 220.0 mm (Middle of the Strain Gauge Grid to loading point) Width of the Beam (b) : 28.0 mm

Thickness of the Beam (t) : 2.5 mm

S P E C I F I C A T I O N

DISPLAY RANGE : 31/2 digit RED LED display of 200 mV FSD to read up to +/-1999 microstrain .

GAUGE FACTOR SETTING : 2.1

BALANCE : Potentiometer to set zero on the panel.

BRIDGE EXCITATION : 10V DC BRIDGE

CONFIGURATIONS : Full Bridge. MAX. LOAD : 1Kg.

POWER : 230 V +/- 10% at 50Hz. with perfect grounding.

All specifications nominal or typical at 23^0 C unless noted.

CANTILEVER BEAM SPECIFICATION

MATERIAL : Stainless Steel BEAM THICKNESS (t) : 0.25 Cm.

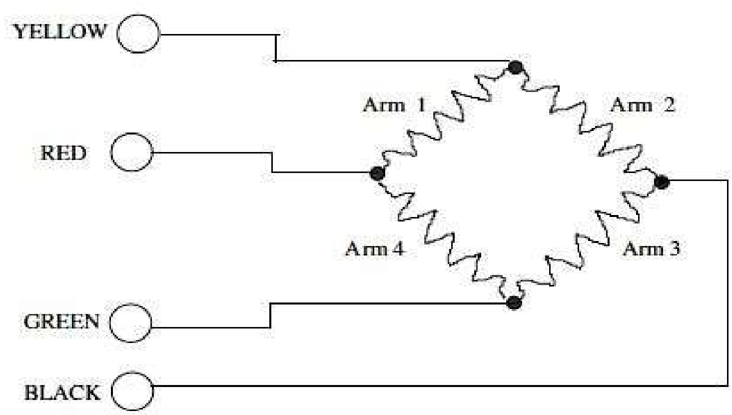
BEAM WIDTH (b) : 2.8 Cms. BEAM LENGTH (Actual) : 22 Cms. YOUNGS MODULUS (□□) : 2 X 10^6 Kg / cm2.

STRAIN GAUGE : Foil type gauge

GAUGE LENGTH (l) : 5 mm

GAUGE RESISTANCE (R) : 300 Ohms. GAUGE FACTOR (g) : 2.01

CONNECTION DETAILS



OPERATING PROCEDURE

1. Check connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON Position for 10 minutes for initial warm-up.
3. Adjust the ZERO Potentiometer on the panel till the display reads '000'.
4. Apply 100 grams load on the cantilever beam and adjust the CAL potentiometer till the display reads. (as per calculations given below) Remove the weights the display should come to ZERO incase of any variation adjust the ZERO pot again and repeat the procedure again.
5. Apply load on the sensor using the loading arrangement provided in steps of 100g upto 1Kg.

6. Note down the readings in the tabular column. Percentage error in the readings, Hysteresis and Accuracy of the instrument can be calculated by comparing with the theoretical values.

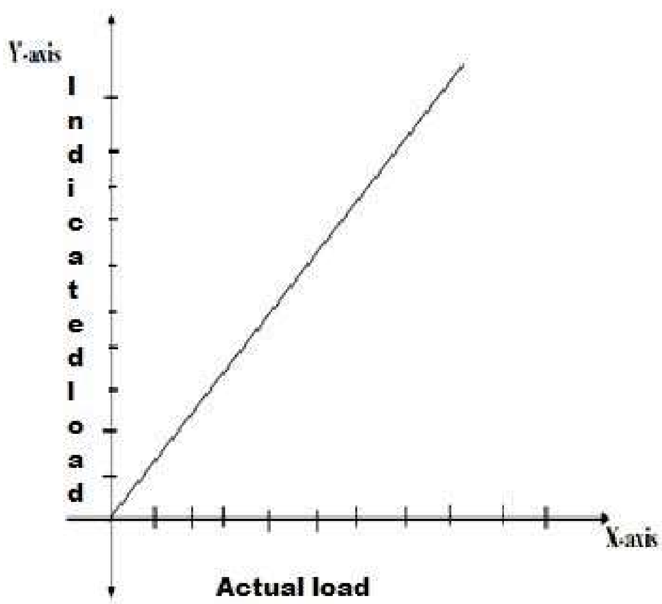
OBSERVATIOPN TABLE

A S No	B Weight (in grams)	D Indicator readings (grams)	ERROR in %
1			
2			
3			
4			
5			

% ERROR = [(Actual Reading (C) - Indicator Readings (D)] x 100

Max. Weight in gms

`**Graph:** Graph Plotted Actual Readings (X-axis) Vs Indicator Readings (Y-axis)



Result: thus calibrated cantilever beam subjected to concentrated end load.

Instrumentation

LAB MANUAL

lendi

LIET-MED

DEPARTMENT OF MECHANICAL ENGINEERING

Do's:

- Wear appropriate safety gear (gloves, goggles, and aprons).
- Ensure proper machine guarding before operation.
- Keep the workspace clean and free of obstructions.
- Report any spills, accidents, or damaged equipment immediately to the lab supervisor.

Don'ts:

- Do not operate machines without prior training.
- Avoid wearing loose clothing or accessories near rotating machinery.
- Never leave a running machine unattended.