

WEST GODAVARI INSTITUTE OF SCIENCE & ENGINEERING

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AVAPADU, PRAKASARAOPALEM – 534 112, W.G.Dist., A.P

**MEASUREMENTS & METROLOGY
LAB MANUAL-R20**

DEPARTMENT OF MECHANICAL ENGINEERING

III B.TECH II SEMESTER

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

KAKINADA–533003, Andhra Pradesh, India

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MEASUREMENT OF LENGTH, HEIGHT & DIAMETER BY
VERNIER CALIPERS

1. **AIM:** To measure Length, Height and Diameter of given objects by using Vernier Calipers & Micrometer.
2. **APPARATUS:** Vernier Calipers, Outside Micrometer & Objects
3. **DESCRIPTION:**

Pierre Vernier, a Frenchman, devised principle of Vernier for precise measurements in 1631. The Vernier Caliper consists of two scale one is fixed and the other is movable. The movable scale, called Vernier Scale. The fixed scale is calibrated on L-shape frame and carries a fixed jaw. The Vernier scale slides over the main scale and carries over the movable jaw. Also an arrangement is provided to lock the sliding scale on fixed main scale.

Principle of Vernier Caliper:

The principle of Vernier is based on the difference between two scales or divisions, which are nearly, but not quite alike for obtaining small difference. It enables to enhance the accuracy of measurement.

Least Count:

Least count is the minimum distance which can be measured accurately by the Instrument.

Least Count of Vernier Caliper is the difference between the value of main scale division and Vernier Scale Division.

Thus Least Count = (Value of Smallest Division on Main Scale) -
(Value of Smallest Division on Vernier Scale)

$$= 1 - 49/50$$

$$= 0.02 \text{ mm.}$$

(or) Least Count = (Value of Minimum Division on the Main Scale) / (Number of Division on Vernier Scale) = $1/50 = 0.02 \text{ mm.}$

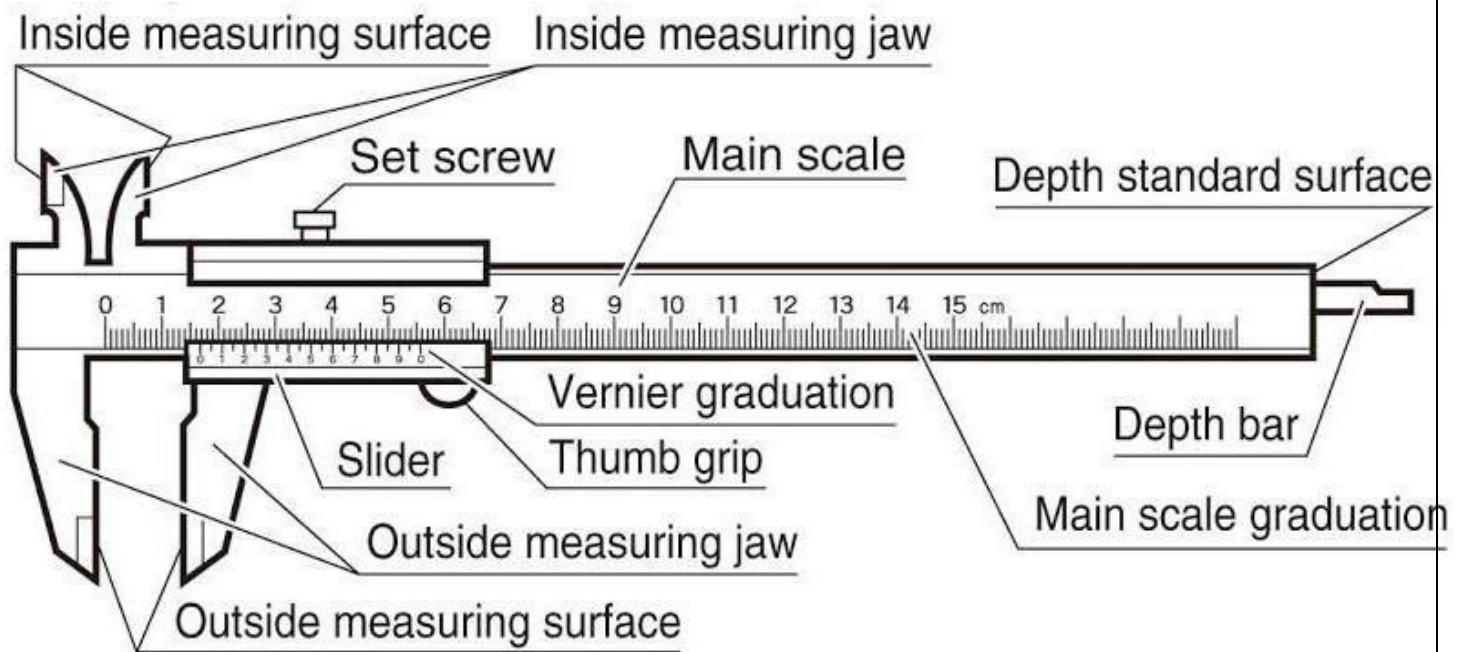


FIG. VERNIER CALLIPERS

4. PROCEDURE:

The given component is fixed between the jaws firmly, i.e.. in between fixed jaw and movable jaw.

The reading is to be noted down.

Procedure for taking the Reading:

1. After closing the jaws on the work surface, take the readings from the main as well as Vernier Scale. To obtain the reading, the number of divisions on the main scale is first read off. The Vernier Scale is then examined to determine which of its divisions coincide or most coincident with a division on the main scale.
2. Before using the instrument should be checked by zero error. The zero line on Vernier Scale should coincide with zero on the main scale.
3. Then take the reading in mm on main scale to the left of zero on sliding scale.
4. Now Count the no. of divisions on Vernier Scale from zero to a line which exactly coincides with any line on the main scale.

Thus total reading = [Main scale reading] + [No. of divisions with a division on Main Scale] X Least Count.

$$(OR) TR = MSR + VC \times LC$$

5. Take the reading for 4 times.

Sample Reading :**TABULAR FORM :**

SLNO.	MSR	VC	TR

The length / dia / height = Average of the readings
 $= (Trial\ 1+2+3+4+5) / 5 = \text{----- mm}$

RESULT:

Length / Diameter / Height = ----- mm

OUTSIDE MICROMETER

AIM : To determine outside diameter of component taken

APPARATUS: Components to be measured outside micrometer.

DESCRIPTION:

Micrometers are designated according to screw and nut principle where a calibrated screw thread and a circular scale divisions are used to indicate the principle practical part of main scale divisions.

The semi circular frame carries a fixed anvil at one extremely and cylindrical barrel at the other end. A fine accurately cut screw of uniform pitch is machined on a spindle. The spindle passes through the barrel and its left hand side constitutes the movable anvil. A sleeve fits on the screw and carries on its inner edge a circular scale divided - into desired no. of divisions. The spindle with its screw and thimble are in one piece and sleeve forms the nut. The thimble scale serves to measure the friction of its circular rotations. The number of complete rotations is read from main scale, which is graduated in 'mm' on nut parallel to axis of screw.

PROCEDURE:

The work piece is held between the 2 anvils without undue pressure. This is Accomplished by having a ratched drive to turn the thimble when the anvils contact each other directly or indirectly through work piece placed in between the ratchet tips over the screw cap without moving the screw forwards and thus avoids undue pressure.

Least Count = Pitch of the screw/ No. of Divisions on Circular Scale. If Pitch of screw is 0.5 mm and Circular Scale has 50 divisions on it, then

$$\text{Least Count} = 0.5 / 50 \sim 0.01 \text{ mm}$$

In measuring, the dimension of work piece the main scale upto the leveled edge of thimble and no. of divisions of thimble scale to axial line on barrel are observed addition of two given result.

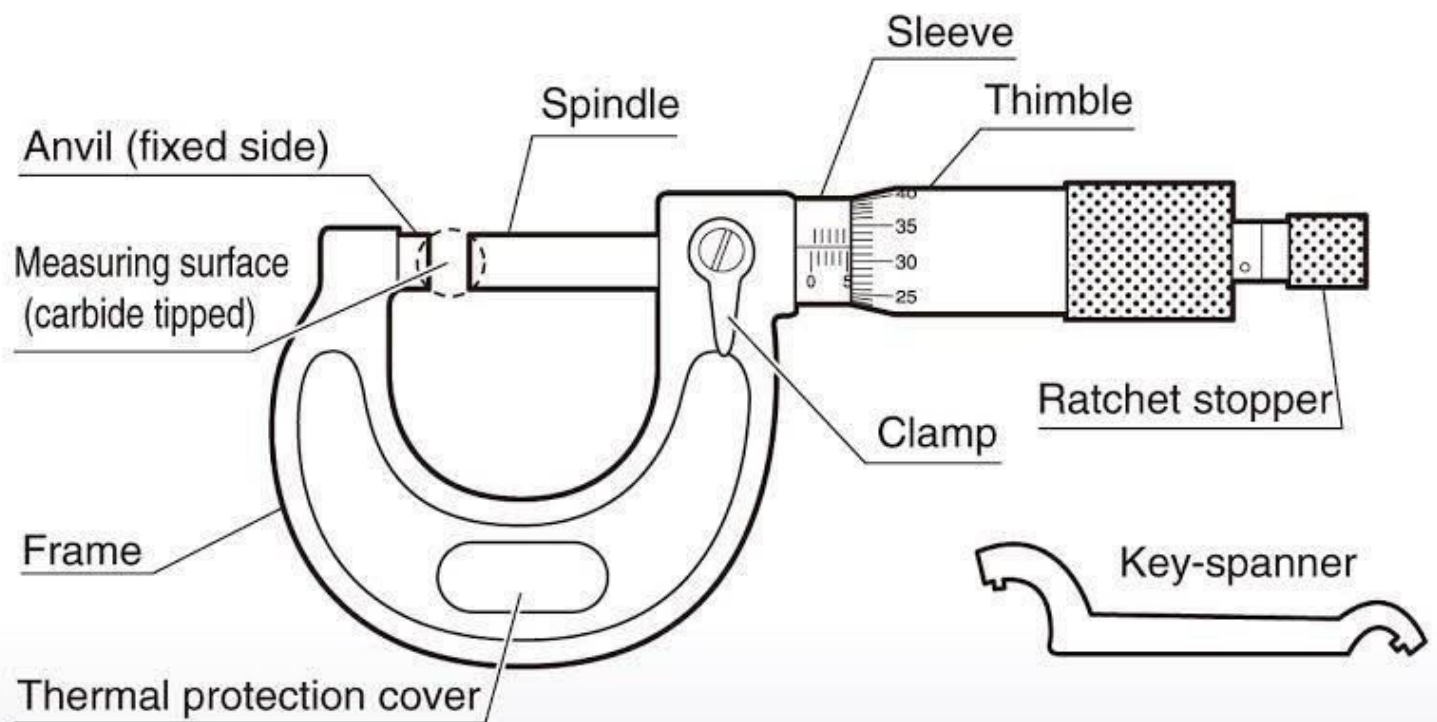


FIG. OUTSIDE MIROMETER

OBSERVATIONS :

Measuring the below given component with 0-25 , 0.01 mm Micrometer.

SAMPLE CALCULATIONS:

$$TR = SR + (CSR \times LC)$$

TR = TOTAL READING ; SR = SLEVE READING ; CSR =

CIRCULAR SCALE READING ; LC = LEAST COUNT

TABLE FORMAT :

SLNO.	MSR	VC	TR

..... The average diameter of the component is

..... mm.

PRECAUTIONS :

The thimble should be turned with ratchet only and to have standard condition and to prevent excess deformation of work piece.

RESULT:

The required outer diameter of the given components using outside micrometer is obtained.

MEASUREMENT OF GEAR TOOTH THICKNESS

AIM:

To measure spur gear tooth thickness by using Gear tooth vernier.

INSTRUMENTS AND MATERIAL REQUIRED :

- a) Gear tooth vernier caliper
- b) Spur gear

SPECIFICATIONS:

- a) Gear Tooth vernier calipers – range 0-150 mm , LC = 0.02mm
- b) Spur gear size = Standard size
- c) Vernier calipers - range 0-150 mm, LC = 0.02mm

TERMINOLOGY OF GEAR TOOTH : Fig (3.1)

Pitch circle diameter (P.C.D): It is the diameter of a circle which by pure rolling action would produce the same motion as the toothed gear wheel.

Module (m) : It is defined as the length of the pitch circle diameter per tooth. Thus if P.C.D of gear be 'D' and number of teeth 'N', then module (m) = D/N . it is generally expressed in mm.

Diametric pitch : It is expressed as the number of teeth per inch of the P.C.D.

Circular pitch : It is the arc distance measured around the pitch circle from the flank of one tooth to a similar flank in the next tooth. $C.P = \pi D/N = \pi m$

Addendum : This is the radial distance from the pitch circle to the tip of the tooth. Its value is equal to one module.

Clearance : This is the radial distance from the tip of a tooth to the bottom of a mating tooth space when the teeth are symmetrically engaged. Its standard value is 0.157 m

Dedendum : This is the radial distance from the pitch circle to the bottom of the tooth space.

Dedendum = Addendum + clearance = $m + 0.157 m = 1.157 m$.

Blank diameter : This is the diameter of the blank from which gear is cut. It is equal to P.C.D plus twice the addendum.

Blank diameter = $P.C.D + 2m = mN + 2m = m(N+2)$

Tooth thickness : This is the arc distance measured along the pitch circle from its intercept with on flank to its-intercept with the other flank of the same tooth.

Normally tooth thickness = $1/2 (C.P) = 1/2 (\pi m)$

But thickness is usually reduced by certain amount to allow for some amount of backlash and also owing to addendum correction.

Face of tooth : It is that part of the tooth surface which is above the pitch surface.

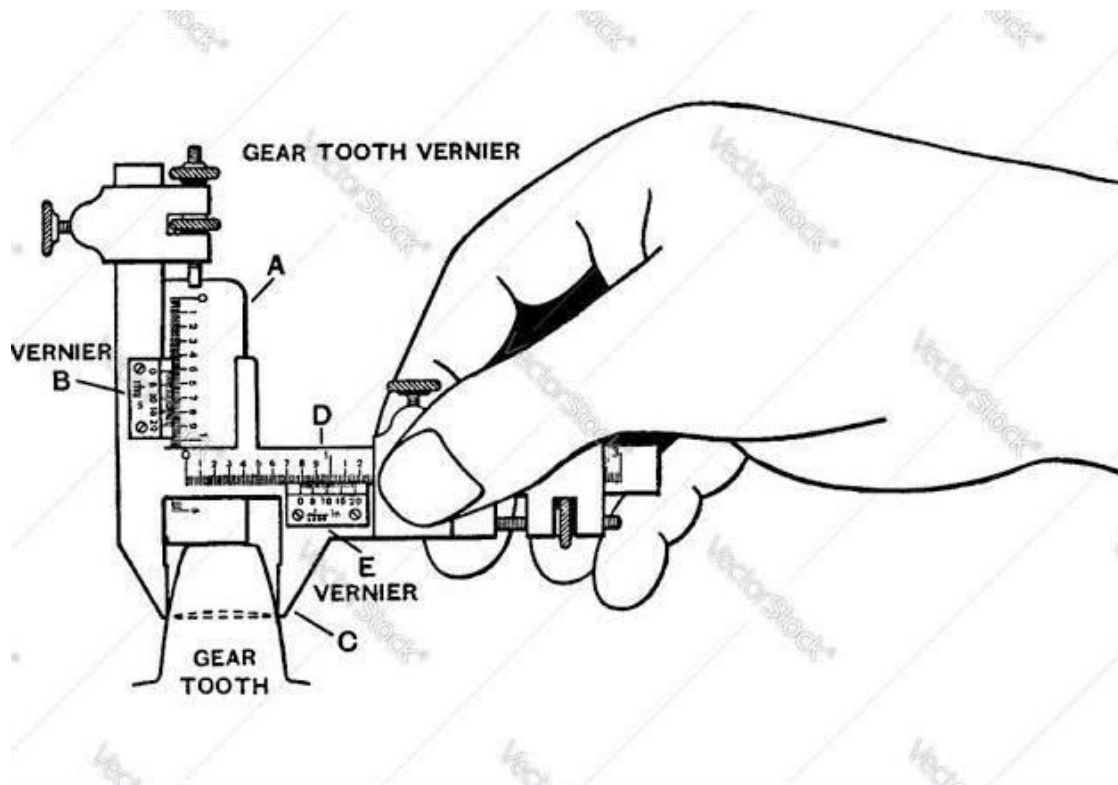
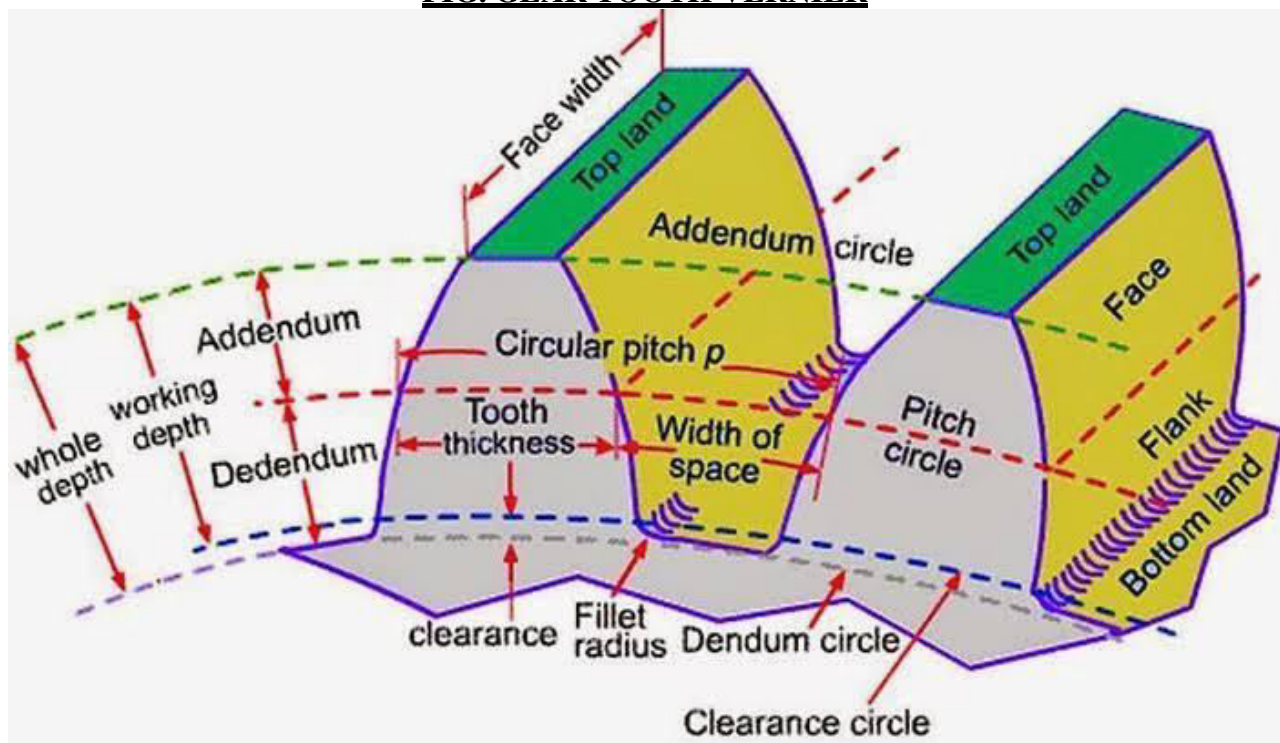
Flank of tooth: It is that part of the tooth surface which is lying below the pitch surface.

PRINCIPLE :

MEASUREMENT OF TOOTH THICKNESS :

The permissible error or the tolerance on thickness of tooth is the variation of actual thickness of tooth from its theoretical value. The tooth thickness is generally measured at pitch circle and is therefore, the pitch line thickness of tooth i.e., length of an arc, which is difficult to measure directly. In most of the cases, it is sufficient to measure the chordal thickness i.e, the chord joining the intersection of the tooth profile with the pitch circle. Also the difference between chordal tooth thickness and circular tooth thickness is very small for gear of small pitch. The thickness measurement is the most important measurement because most of the gears manufactured may not undergo checking of all other parameters, but thickness measurement is a must for all gears.

The tooth thickness can be very conveniently measured by a gear tooth vernier. Since the gear tooth thickness varies from the tip to the base circle of the tooth, the instrument must be capable of measuring the tooth thickness at a specified position on the tooth. Further this is possible only when there is some arrangement to fix that position where the measurement is to be taken. The gear tooth vernier has two vernier scales and they are set for the width (w) of the tooth and the depth (d) from the top, at which 'w' occurs.

**FIG. GEAR TOOTH VERNIER****FIG. TERMS IN GEAR TOOTH**

PROCEDURE:

Count the number of teeth (N) on the gear,

Measure the outside diameter (D_o) of the gear.

Calculate the module from the relation, $m = D_o / (N + 2)$

Calculate the value of chordal addendum (d) from equation

Set the gear tooth vernier caliper for depth 'd' and measure 'w' i.e., chordal thickness of tooth.

Repeat the measurement on other teeth and determine an average value.

OBSERVATIONS:

- a) Number of teeth on gear, $N = \text{-----}$
 b) Outside diameter of gear (D_o) = -----

SMALL GEAR :

- c) Number of teeth on gear, $N = \text{-----}$
 d) Outside diameter of gear (D_o) = -----

Width :

M.S.R	V.S.R \times L.C	T.R

Height :

M.S.R	V.S.R \times L.C	T.R

LARGE GEAR :

- e) Number of teeth on gear, $N = \text{-----}$
 f) Outside diameter of gear (D_o) = -----

Width :

M.S.R	V.S.R \times L.C	T.R

Height :

M.S.R	V.S.R \times L.C	T.R

CALCULATIONS:

Chordal addendum (d) = $(Nm)/2(1 + 2/N - \cos(90/N))$

chordal thickness (w) = $N.m \sin(90^\circ/N) = \underline{\hspace{2cm}}$

module (m) = $D_o/(N+2)$

Pressure angle(θ) = D_b/D_p

Base pitch(P_b) = $\frac{(Z-Y)+(Y-X)}{2}$ $P_b = \frac{\pi D_b}{T}$ $D_b = \frac{TP_b}{\pi}$

$D_b = \text{Pitch diameter} \times \cos \theta$

where, X = Width of two teeth

Y = Width of three teeth

Z = Width of four teeth

Base circle diameter(D_b)

PRECAUTIONS:

- i) Don't press the jaws too tight.
- ii) See the reading without parallax error.

RESULTS:

The theoretical value of gear tooth thickness may differ from the measured value due to the manufacturing inaccuracies.

CALCULATIONS:

i) Chordal addendum (d) = $(N.m)/2(1 + 2/N - \cos(90/N))$

ii) chordal thickness (w) = $N.m \sin(90^\circ/n) = \text{-----}$

PRECAUTIONS:

- i) Don't press the jaws too tight.
- ii) See the reading without parallax error.

RESULTS:

The theoretical value of gear tooth thickness may differ from the measured value due to the manufacturing inaccuracies.

MACHINE TOOL TESTING

INTRODUCTION:

The surface components produced by machining processes are mostly by generation. As a result, the quality of surface produced depends upon the accuracy of the various movements of the machine tool concerned. It therefore becomes important to know the capability of the machine tool by evaluating the accuracy of the various mechanisms that are directly responsible for generating the surface. For this purpose a large variety of tests have been designed.

MEASURING INSTRUMENTS USED FOR TESTING:

The accuracy of the machine tools employed should be higher than the accuracy of the components that it produces. Similarly the quality of the measuring equipment used for machine tool testing should be commensurate with the quality expected from such testing. A few commonly used equipments are

- Dial Indicators
- Test mandrels
- Straight edges
- Spirit levels

TEST PROCEDURES:

The major tests that are conducted on machine tool are:

- Testing the quality of the slide ways and the locating surfaces
- Testing the accuracy of the main spindle and its alignment with respect to other parts of the machine tool.
- Testing the accuracy of the parts produced by the machine tool.

ACCEPTANCE TESTS

LATHE MACHINE

Tests that can be conducted on Lathe machine:

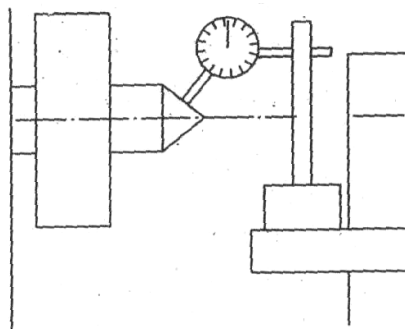
1. **Quality of slide ways:** To test the quality of the slide ways it is necessary to mount the dial indicator on a good datum surface. Then the plunger is moved

along the longitudinal direction of the slide ways which provides an indication of the undulations present on the surface of the slide ways.

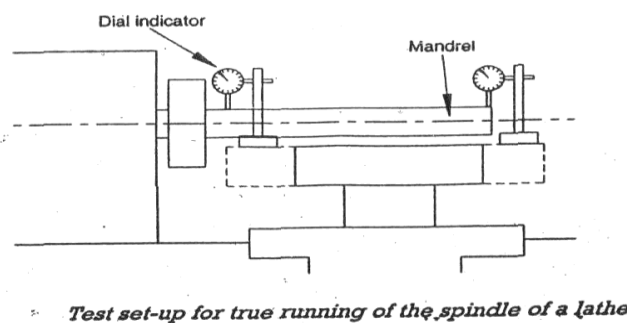
2. Accuracy of the spindle:

These tests are related to the true running of the spindle and the centre located in the spindle along with the alignment, parallelism and perpendicularity of the spindle with the other axes of the concerned machine tool.

True running of the centre: The live centre may be loaded into the lathe spindle and a dial indicator mounted as shown in fig. This test is required only for machines where the work piece is held between centres. The readings of the dial indicator are taken while rotating the spindle through full rotation.



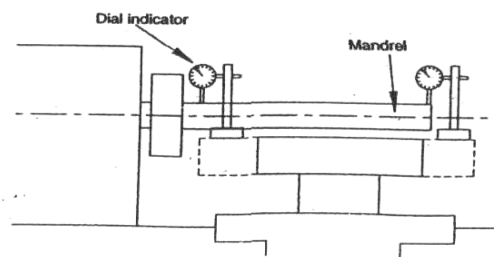
True running of the spindle: the taper shank of the test mandrel of about 300 mm length is mounted into the spindle as shown in fig. The plunger of the dial indicator rests on the cylindrical surface of the mandrel. The spindle is rotated slowly and the readings of the dial indicator are noted. The deviation should normally be less than 0.01mm. The test is to be repeated with the dial indicator positioned close to the spindle bore as well as at the extreme end of the test mandrel.



Squareness of the face: this test is used to measure the squareness of the shoulder face with reference to the spindle axis. The plunger of the dial indicator rests on the extreme radial position of the shoulder face and the reading is taken. It is repeated by slowly rotating the spindle till the dial indicator comes to a point that is diametrically opposite to the reading taken earlier.

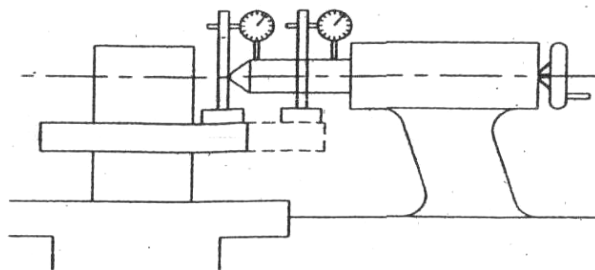
3. **Alignment tests:**

Parallelism and perpendicularity: Parallelism and perpendicularity between two axes or two surfaces is normally measured in two planes, horizontal and vertical. For this purpose the test mandrel is mounted in the spindle as shown in fig. with dial indicator mounted on the saddle or carriage. The plunger of the dial indicator touches the mandrel surface as shown in fig. the saddle is moved for a specified distance and the dial reading noted. The test is repeated in the horizontal direction as well.



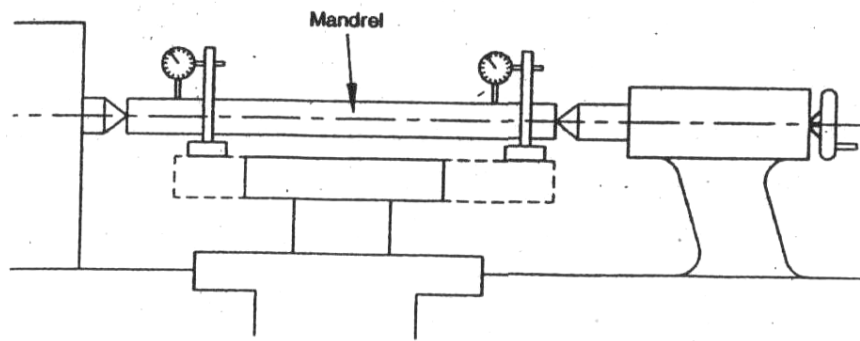
Test set-up for parallelism between the spindle axis and the slideways in a lathe

Parallelism between the outside diameter of the tail stock sleeve and the slide ways as shown in fig.



Test set-up for the parallelism of the tail stock sleeve

Parallelism between the line of centres and the slide ways shown in fig.

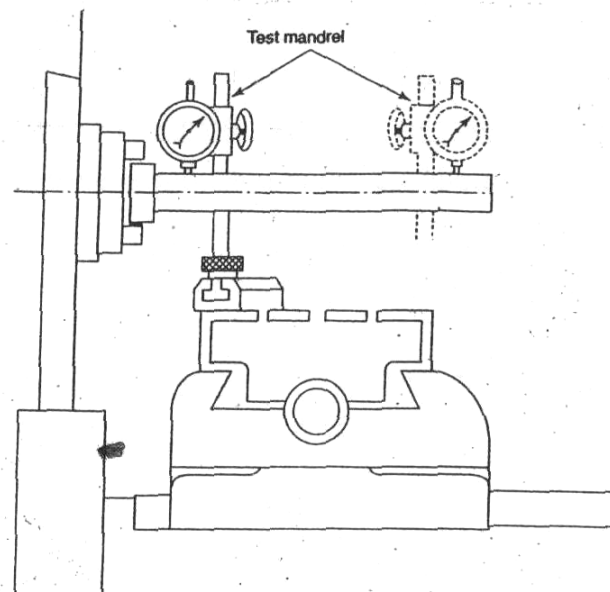


Test set-up for parallelism of the line of centres in a lathe

MILLING MACHINE:

The following tests can be conducted:

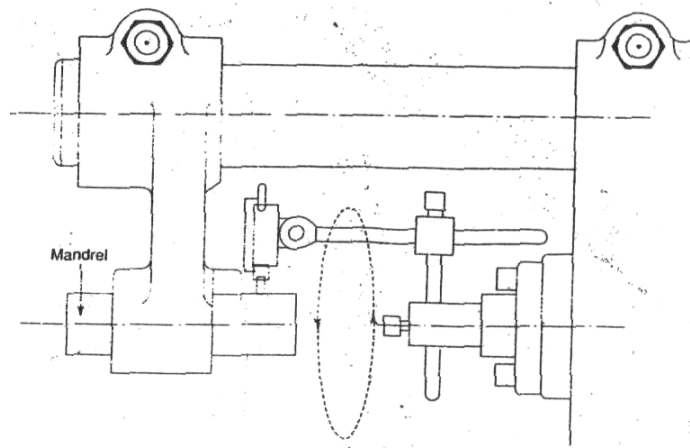
1. True running of the spindle:



Test set-up for true running of the spindle of a milling machine

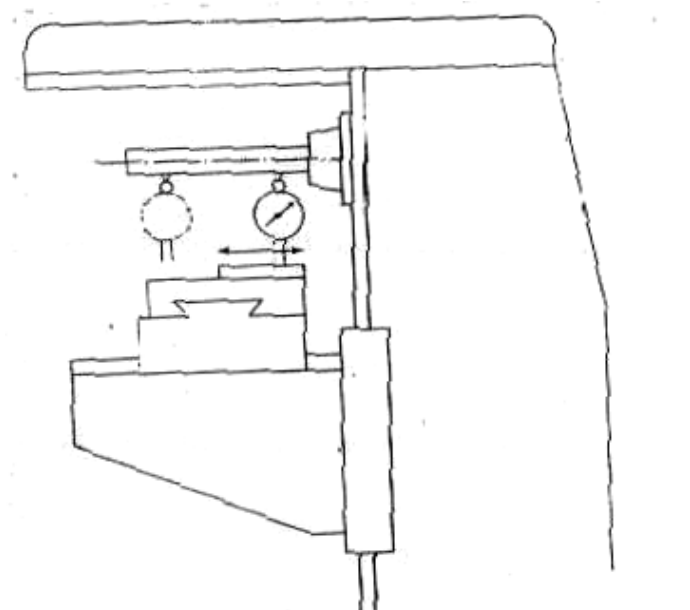
2. Spindle alignment:

In this test dial indicator is mounted on one of the surfaces whose alignment is to be tested with another surface. In case of a horizontal milling machine the testing of the alignment between the spindle and the over arm support can be done as shown in fig.



The dial indicator is mounted on the spindle while a test mandrel is mounted in the over arm support with the plunger of the dial indicator resting on the cylindrical surface of the test mandrel. The spindle is rotated and readings are taken when it is at different positions on the periphery of the test mandrel. The test may be conducted at two extreme ends of the mandrel.

Parallelism between the table and the spindle axis shown in fig. A test mandrel 300mm long is mounted in the spindle axis and the dial indicator is mounted on the table. The reading of the dial indicator is taken at the two extreme positions without the table movement.



Test set-up for parallelism between the table and the spindle axis in a horizontal milling machine

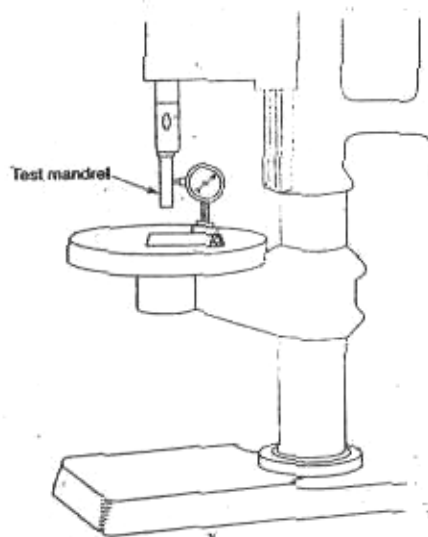
Other tests that can be conducted are:

- Parallelism between the spindle axis and the transverse movement of the table.
- Perpendicularity between the spindle and the vertical column ways.

RADIAL DRILLING MACHINE:

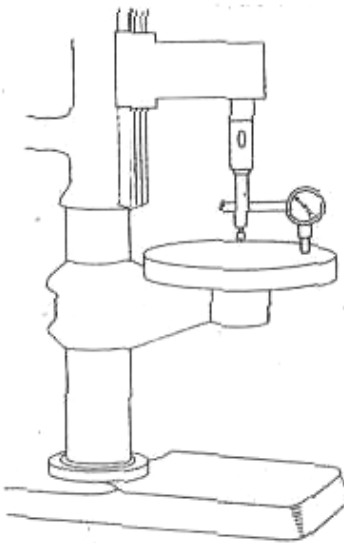
Tests that can be conducted on Drilling Machine are:

1. True running of the spindle.

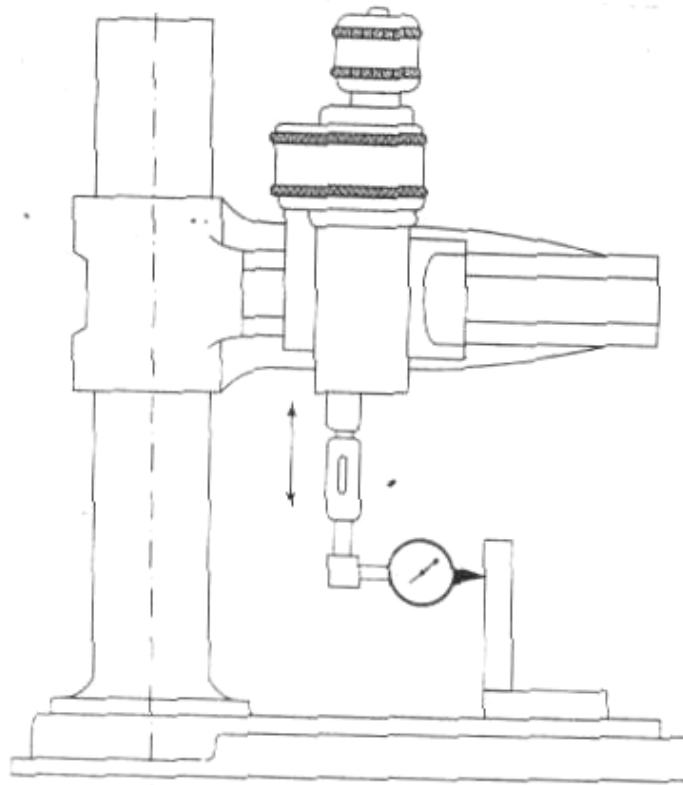


Test set-up for true running of the spindle of a radial drilling machine

2. Perpendicularity between the spindle and the base plate.



3. Perpendicularity between the feed movement and the base plate.



Test set-up for the perpendicularity between the feed movement and the base plate of a radial drilling machine

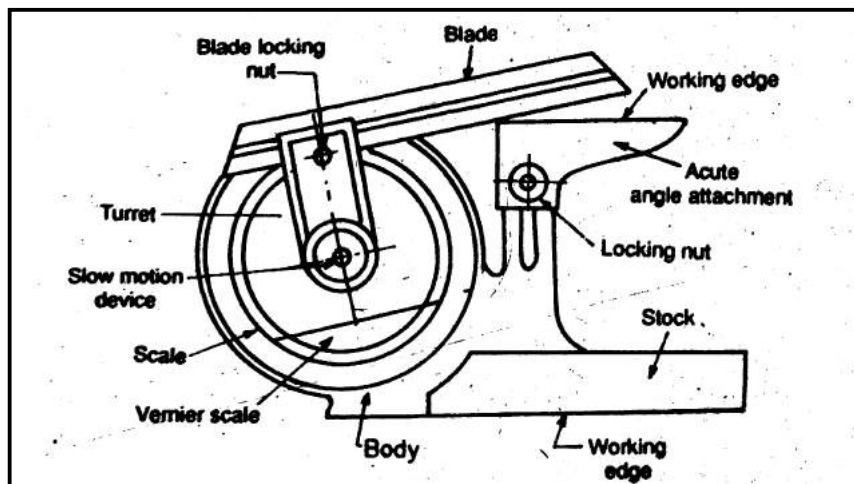
MEASUREMENT OF ANGLES – UNIVERSAL BEVEL PROTRACTOR

AIM: To find out the various angles of the given specimen using universal bevel protractor

APPARATUS: Universal bevel protractor with accessories

THEORY: The bevel protractor is used to measure the various angles of both small and large components with accuracy up to 5 minutes. The design of the universal bevel protractor type had considerably increased the scope of angular measurement with the adjustable blades and the protractor can be indexed through 360° . The same basic principle as in the other vernier scales was used in this instrument.

CONSTRUCTIONAL DETAILS & APPLICATIONS:



LEAST COUNT: The vernier scale of the protractor had 24 equal divisions with 12 divisions on each side of zero. On each side 12 divisions are marked from 0-60 and occupying 23 divisions on the main scale. Each division on vernier scale measures $23/12^{\circ}$. Therefore least count is the difference between one main scale division and one vernier scale division $[2^{\circ} - 23/12^{\circ} = 1/12^{\circ} = 5']$ Once the least count was known the method of taking the reading is as usual.

PROCEDURE:

1. The appropriate size blade to suit the given job was fixed and locked.
2. The job / component was placed by touching the reference face and the movable blade.
3. The blade was locked after ensuring the proper contact on the two faces of the job.
4. The reading was noted down corresponding to the zero of the vernier scale.
(M.S.R + V.S.C x 1/12)
5. The procedure was repeated to find out all the required angles.

PRECAUTIONS:

1. The blades should be fined tightly without any play.
2. Blade should be clamped only after ensuring the contact of the blade over the entire length of the component.
3. The instrument should be cleaned before and after use.
4. Vernier coincidence should be taken without parallax error

OBSERVATIONS:**SPECIMEN – 1:**

$\theta_1 =$
 $\theta_2 =$
 $\theta_3 =$

SPECIMEN – 2:

$\theta_1 =$
 $\theta_2 =$
 $\theta_3 =$

RESULT:

The angles of the various corners of the given specimen were found to be as follows.

$\theta_1 =$

$\theta_2 =$, $\theta_3 =$

MEASUREMENT OF TAPER ANGLES – SINE BAR

AIM: To find out the taper angle of a given specimen using sine bar

APPARATUS:

1. Sine bar
2. Dial gauge
3. Dial gauge stand
4. Slip gauge set
5. Surface plate

THEORY & PRINCIPLE: The high degree of precision available for linear measurement in the form of slip gauges can be utilised for the measurement of angles with the aid of a very simple and best measuring tool known as sine bar. The principle involved in this measurement was that the sine bar, slip gauges and the datum surface i.e. surface plate on which they lay form a right-angled triangle. The sine bar forms as hypotenuse of the right angled triangle and the slip gauges form the side opposite to the required angle. If θ is the angle to be measured and if H is the height of slip gauge and L is the length of the sine bar, from the right-angled triangle.

$$\sin\theta = \frac{H}{L}$$

CONSTRUCTIONAL DETAILS & APPLICATIONS: Sine bar (Refer any text book)

PROCEDURE:

1. The surface plate was considered as the datum to conduct the experiment.
2. The component whose angle is to be checked was mounted securely on the sine bar and both are placed on the surface plate.
3. The sine bar along with the component was set at an approximate angle by placing a known size of slip gauge at one end of the sine bar, so that the tapered side of the component is made parallel to the surface plate.
4. The dial gauge mounted on a suitable stand was placed adjacent to the sine bar so that the plunger just slides on the surface of the component. At one end the dial gauge was adjusted to read zero.

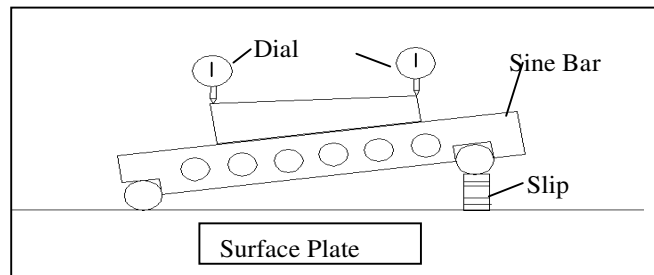
5. The same dial gauge was placed at the other end of the component and the reading is noted.
6. The height of slip gauges under the sine bar was adjusted until the dial gauge read zero at both ends of the component and the corresponding slip gauge size was noted down.
7. The acute angle made by the sine bar with the surface plate is the taper angle of the component, which was measured by using the following formula.

$$\theta = \sin^{-1}(H/L) \quad \text{---}$$

PRECAUTIONS:

1. The surface plate, slip gauge set and sine bar should be degreased properly.
2. The dial gauge should be clamped to the stand properly so that the plunger is vertical to the base.
3. The dial gauge plunger should be handled gently and the gauge was set to zero after giving slight initial compression to the plunger.
4. The slip gauges should be placed gently under the roller of the sine bar.

EXPERIMENT SETUP FIGURE:



OBSERVATIONS:

Length of the sine bar = L mm

Height of the slip gauges = H mm

CALCULATIONS:

$$\text{The Taper Angle } \theta = \sin^{-1}(H/L) = \quad \text{---}$$

RESULT: Taper angle of the specimen “ θ ” =

USE OF SPIRIT LEVEL IN FINDING THE FLATNESS OF SURFACE PLATE**Aim:-**

To check the flatness of given surface plate

Apparatus:-

Spirit level, surface plate

Theory:-

Generally spirit level is used for leveling the machinery and other instruments. But spirit levels are also used to measure the angles. It is also called precision level. It consists of glass tube and of the tube. If the tube is fitted through a small angle if R- radius of tube L .distance of bubble moved when spirit level is fitted to same angle

The angle is calculated as follows

$$L = R\theta$$

$$\theta = L/R$$

Procedure:-

1. Keep the spirit level on the surface plate
2. Observe the bubble in the spirit level
3. If bubble is in the middle of spirit level than surface is flat.
4. If bubble is not in the middle of spirit level than surface is not flat
5. Repeat the same procedure at different places of surface plate.

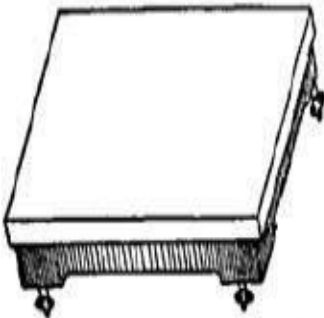
Observations:

S.No	Horizontal(mm)	Vertical(mm)

Result:- The experiment has been conducted on spirit level to check the flatness of given Surface plate

Conclusion:-

The given surface plate is flat/not flat-----



THREAD MEASUREMENT

AIM: To determine the effective diameter of the given threaded specimen using three wire method.

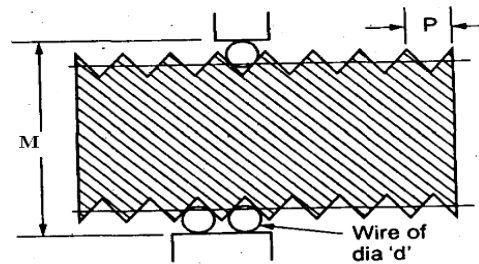
APPARATUS: Outside micrometer, wire set of two wires and one wire.

THEORY: Effective diameter of screw thread is defined as the diameter of an imaginary cylinder co-axial with the axis of the screw, and intersects the flanks of the threads in such a way as to make the widths of threads and widths of the spaces between the threads equal. It can also be defined as the diameter of the pitch cylinder is imagined as generated by a straight line parallel to the axis of the screw that straight line is then referred to as the pitch line. Along the pitch line the widths of the threads and widths of the spaces are equal on a perfect thread. This is the most important dimension as it decides the quality of the fit between the screw and nut.

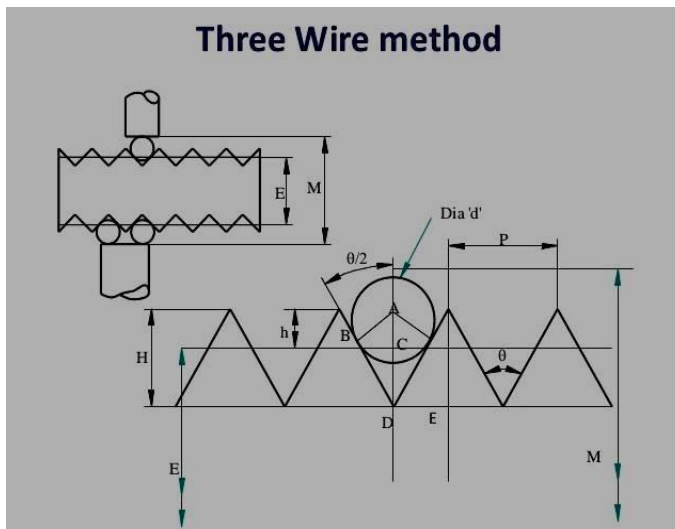
M = measurement, E = Effective Diameter

Three wire method of measuring the effective diameter is an accurate method. In this three wires of known diameter are used. One wire on one side and two on the other side are used as show in fig below

Three Wire method



Three Wire method



From above fig

Let p = Pitch of the thread

M = Measurement over wires

$$= E + 2 A_c + 2r$$

A_c = Height of the centre of the wire from the pitch line

D = diameter of the wire = $2r$

R = radius of the wire = $d/2$

From the fig

$$A_c = AD - CD$$

$\triangle ABD$ is a right angle triangle.

$$\sin \frac{x}{2} = \frac{AB}{CD} \quad AD = \frac{AB}{\sin \frac{x}{2}} = AB \operatorname{cosec} \frac{x}{2}$$

$\triangle CDF$ is a right angle triangle

$$\tan \frac{x}{2} = \frac{CF}{CD} : CF = \frac{1}{4} \text{ of pitch of the thread}$$

$$CD = \frac{\frac{1}{4}P}{\tan \frac{x}{2}} = \frac{p}{4} \cot \frac{x}{2}$$

$$\therefore AC = \frac{d}{2} \operatorname{cosec} \frac{x}{2} - \frac{p}{4} \cot \frac{x}{2}$$

Substituting the value of A_c in equation – 1

$$M = E + 2 \left[\frac{d}{2} \operatorname{cosec} \frac{x}{2} - \frac{p}{4} \cot \frac{x}{2} \right] + 2r$$

$$M = E + d \operatorname{cosec} \frac{x}{2} - \frac{p}{2} \cot \frac{x}{2} + d$$

$$M = E + d \left[1 + \operatorname{cosec} \frac{x}{2} \right] - \frac{p}{2} \cot \frac{x}{2}$$

$$E = M + \frac{p}{2} \cot \frac{x}{2} - d \left[1 + \operatorname{cosec} \frac{x}{2} \right]$$

This method ensures the alignment of micrometer anvil faced parallel to the thread axis.

Once the pitch, thread angle and wire diameter are known, and by measuring the value of M practically the effective diameter can be calculated.

PROCEDURE:

Take the thread specimen and find out the pitch by using a thread pitch gauge. After knowing the pitch, calculate the best wire size by using the formula.

If the thread is Whitworth type best wire size = $0.5637p$

If the thread is Metric type best wire size = $0.577p$

Select the wires corresponding to the calculated value.

Keep the threaded specimen vertically on the surface plate. Stick two wires in adjacent threads with grease and the third wire diametrically opposite to the first two in the same groove. Apply the micrometer over wires and gently rock the anvils against wires. Note down the reading of the micrometer. Repeat the experiment at different positions along the gauge. Usually three or four readings are sufficient.

OBSERVATIONS: Best wire size = mm

S.No.	Sleeve Reads (1)	Thimble reading (2)	Total reading $M=(1)+(2) \times L.C$	Effective Diameter $E = M + \frac{p}{2} \cot \frac{x}{2} - d[1 + \operatorname{cosec} \frac{x}{2}]$
1.				
2.				
3.				

PRECAUTIONS:

1. Do not apply excessive pressure on the micrometer
2. Axis of anvils of micrometer and the axis of screw plug gauge must be perpendicular to each other.

RESULT:

The effective diameter of the given thread specimen =

ANGULAR TYPE CAPACITANCE MEASUREMENT TRAINER

AIM: To calibrate the given capacitive trainer

APPARATUS: Angular Type Capacitance Measurement Trainer

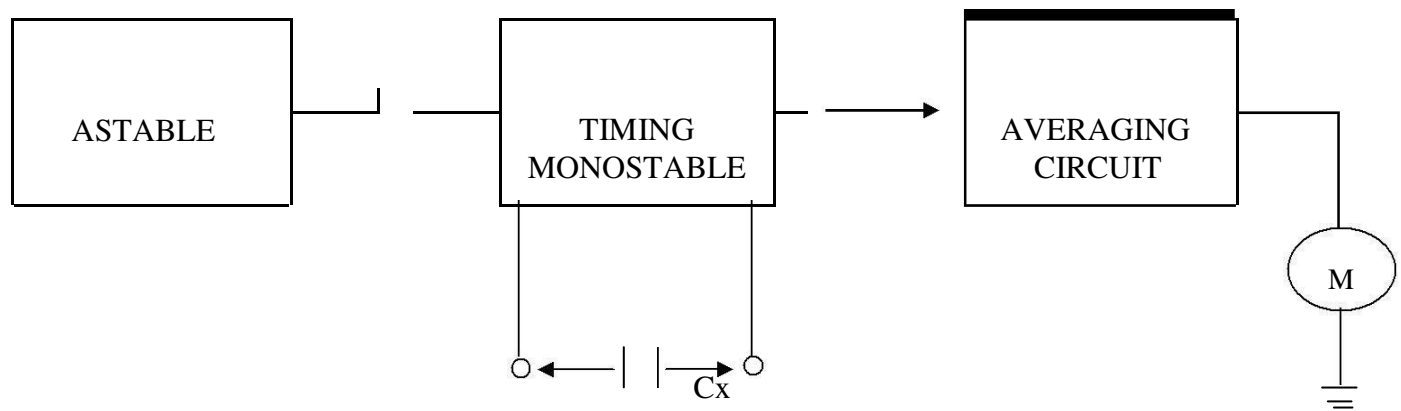
INTRODUCTION:

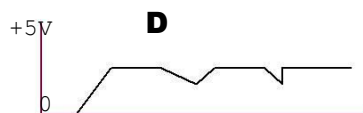
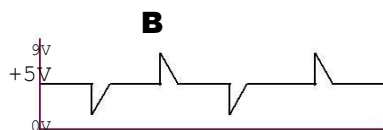
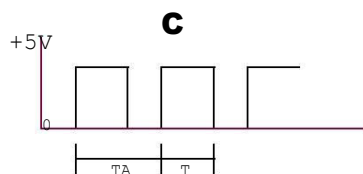
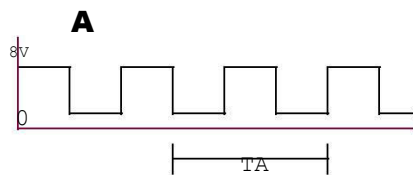
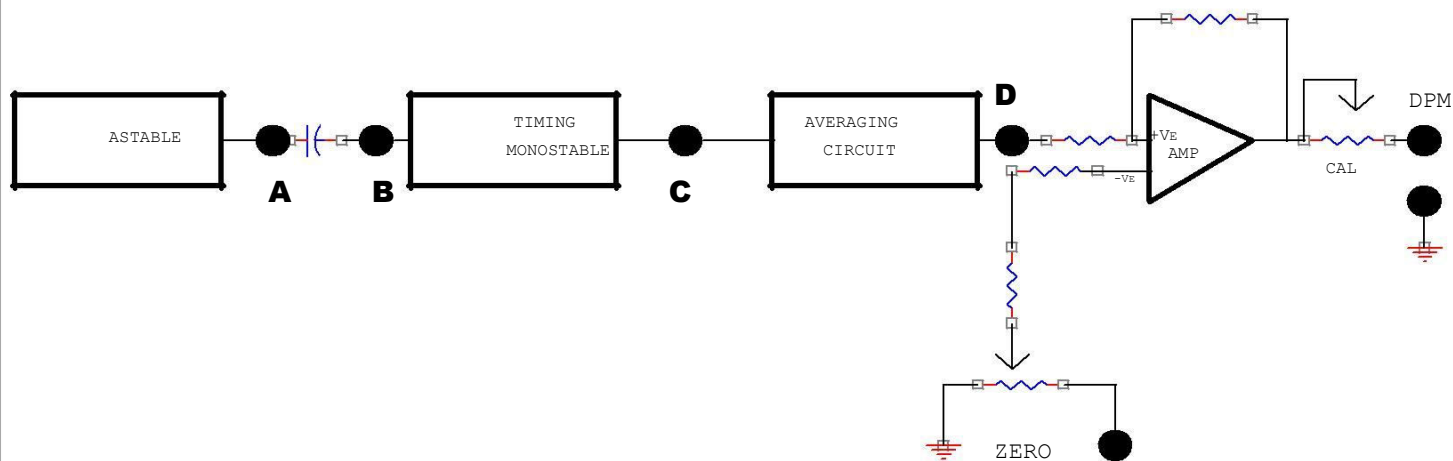
Unique Capacitance trainer Module is the best trainer to demonstrate the use of capacitance as a transducer. Two plates (A1), one fixed to the base and the other moving over the fixed plate parallel with a small gap between the two. The overlapping of the plate will act as a capacitor with air as dielectric media. The parallel plate capacitor is used as a displacement sensor, which measures 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.

The instrument is built around an NE556 integrated circuit. The NE556 is a dual 556 timer IC. The first timer is connected as a stable multi vibrator while the second timer is used as a mono stable.

At each trigger, the mono stable output a pulse whose width is determined by the Resistance and the Capacitance of the parallel plate capacitor C_x connected across the measuring terminals. Specifically, the mono stable duration is given by $T = 1.1 R_{\text{range}} \times C_x$, where R_{range} is the range resistance and capacitance across the measurement terminals. From this it is seen that the width of the mono stable pulse is directly proportional to capacitance C_x (parallel plate capacitor).

Since the mono stable duration is itself is proportional to capacitance C_x (parallel plate capacitor) across the measurement terminals, it follows that the meter indication is directly proportional to the capacitance. The mono stable output is averaged using averaging circuit and feed to amplifier for Zero setting and calibration the instrument to read displacement.

BLOCK DIAGRAM OF ELECTRONIC CAPACITANCE METER

WAVEFORM SKETCHES FOR CAPACITANCE MEASUREMENT

SPECIFICATION

Sensor	:	Angular Plate capacitance.
Sensor Material	:	Aluminum plates
Dielectric Medium	:	Air
1. Displacement	:	0-90 ⁰
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

Check connection made to the instrument

Allow the instrument in ON position for 10 minits for initial warm-up.

Move the moving plate to Zero position.

Adjust the ZERO potentiometer so that the display reads '000'.

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 & 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.

TABULAR COLUMN

A SL. No.	B ACTUAL SCALE READINGS (DEG)	C INDICATOR READINGS CAPACITANCE (DEG)	D ERROR B-C	E % ERROR

RESULT: the given capacitance measurement guage is calibrated.

LVDT MEASUREMENT TRAINER

AIM: To calibrate the given LVDT.

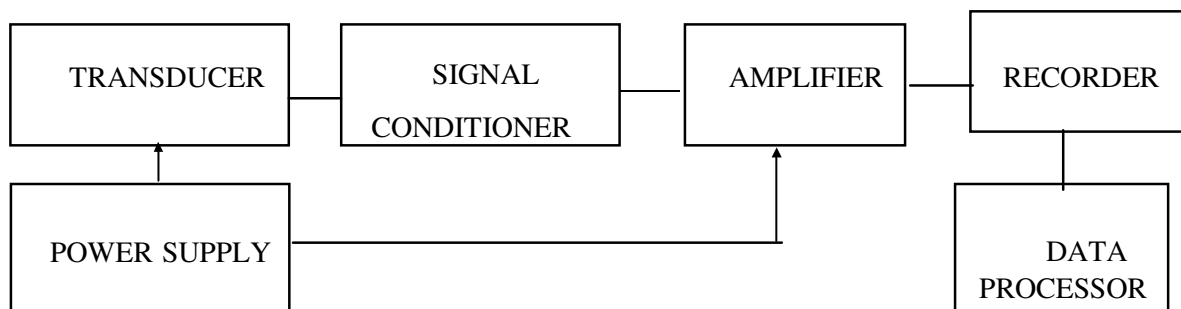
APPARATUS: LVDT measurement trainer

INTRODUCTION:

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.

The **TRANSDUCER** is a device that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



The **POWER SUPPLY** provides the energy to drive the Transducers, example differential transformer, which is a transducer used to measure displacement requires an AC voltage supply to excite 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 strain transducer converts the change in resistance ΔR to a change in the resistance ΔE

AMPLIFIERS are required in the system when the voltage output from the transducer signal conditioner combination is small. Amplifiers with gains of 10 to 1000 are used to increase their signals 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 form that can be read and interpreted. Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the output signals from the instrument system into data that can be easily interpreted by the Engineer. Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

THEORY

MEASUREMENT OF DISPLACEMENT

Differential transformers, based on a variable Inductance principle, are also used to measure displacement. 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 the 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 wired in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induced between the secondary coils are equal but out of phase by 180° . The voltage in the two coils cancels and the output voltage will be zero. When the core 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.

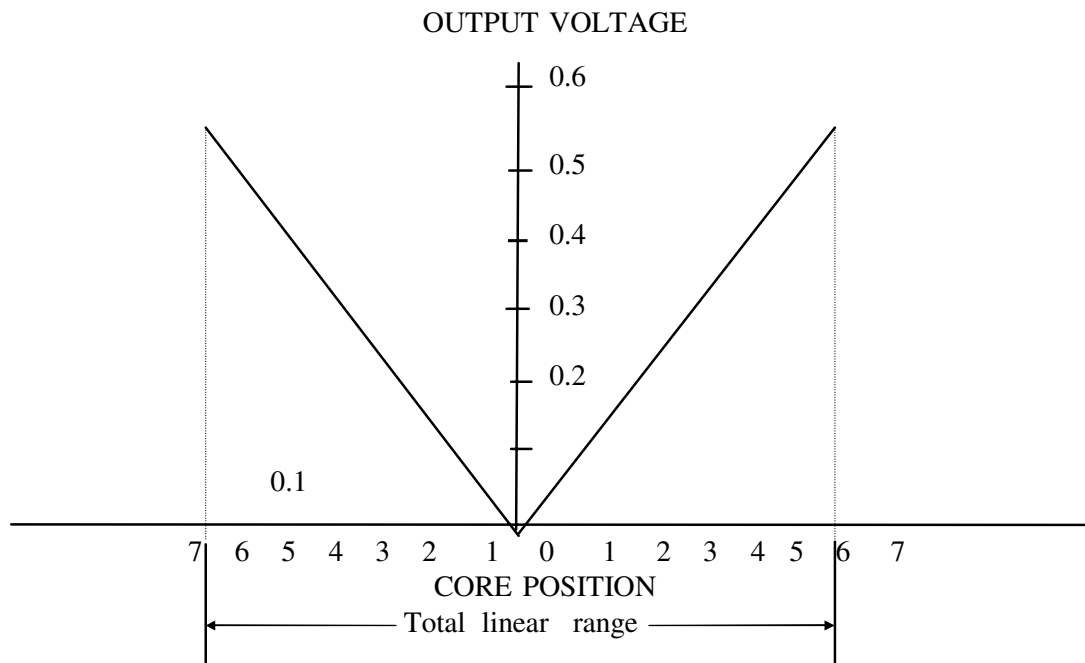


FIG. 1 Magnitude of the output Voltage as a function of LVDT core Position.

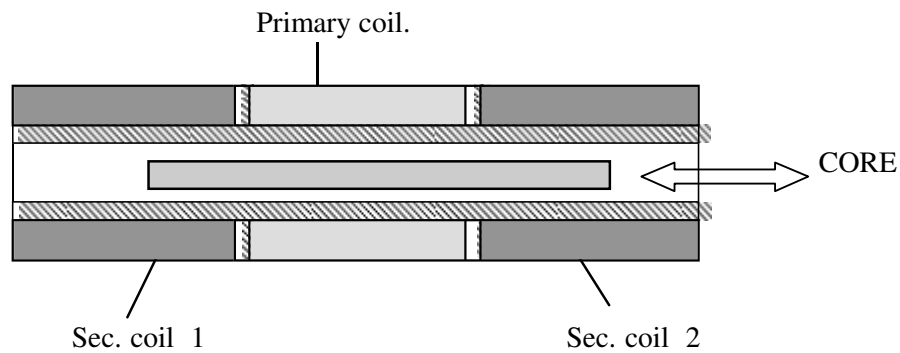


FIG. 2 Diagram to shows schematically the working of LVDT.

CIRCUIT EXPLANATION

The circuit can be divided into three parts.

1. Power supply.
2. Display.
3. Frequency generator
- & 3. Signal Conditioner.

1. POWER SUPPLY.

The power supply unit provides power for all the electronic device in the instrument. There are two different regulated power supply in the unit.

- a) +5V, -5V 250mA too drive digital integrated circuits.
- b) +5V - 0 -5V, 250mA to drive linear integrated circuits.

2. DISPLAY

The display circuit is basically a $3\frac{1}{2}$ digit voltmeter which accepts DC of 200mV for full scale Reading. The display will be indicated through seven segment bright LED's.

3. FREQUENCY GENERATOR

The circuit is an IC based (OP AMP) used to generate excitation voltage to the LVDT primary coil. The IC's use +5 V and -5 V and produce a fine square wave of desired frequency. The Voltage can be adjusted using a trimpot. The square wave is then trimmed by FET, PnP and NpN transistor. Then the Frequency is adjusted by varying the trimpot. The voltage and frequency is adjusted to 2khz 2 V which is fed to LVDT as an excitation voltage.

4. SIGNAL CONDITIONER

The circuit which processes the output of transducers and presents a fixed DC voltage to the display constitute the Demodulator and amplifier. Demodulator is a phase sensitive detector and AC amplifier which gives out DC voltage which is amplified and fed to summing amplifiers. The output of the summing amplifier is fed to the display.

SPECIFICATION**INDICATOR**

- * DISPLAY : $3\frac{1}{2}$ digit seven segment red LED display of range 200mV for full scale deflection. to read \pm 1999 counts.
- * EXCITATION VOLTAGE : 1000 Hz at 1V
- * OPERATING TEMPERATURE : $+10^0$ C to 55^0 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 \pm 10 %, 50 Hz.

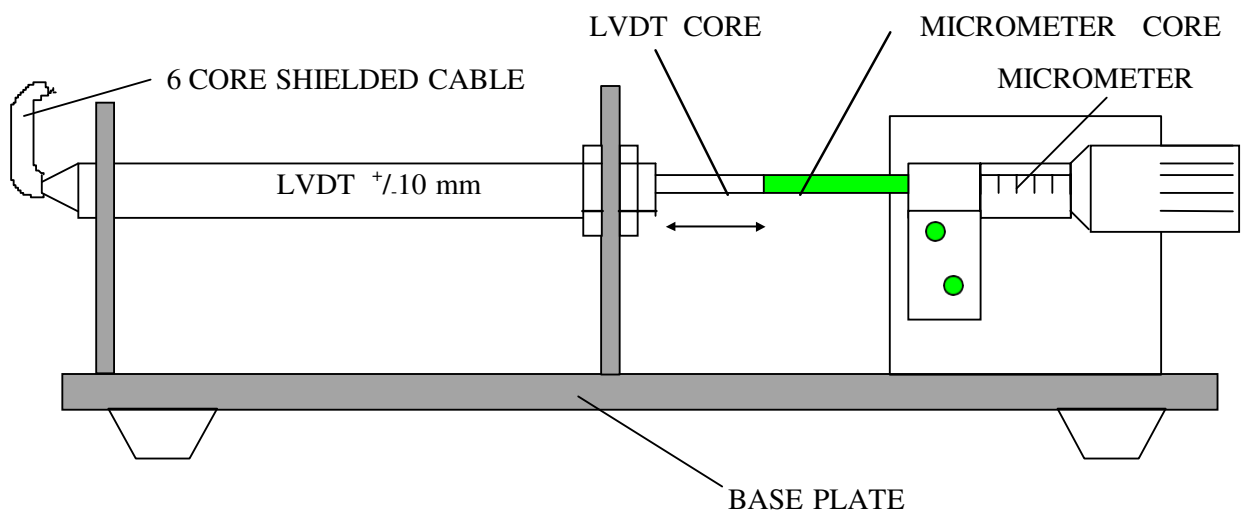
SENSOR

- * RANGE : \pm 10.0 mm
- * EXCITATION VOLTAGE : 1 to 4 kHz at 1 to 4V
- * LINEARITY : 1%
- * OPERATING TEMPERATURE : $+10^0$ C to 55^0 C
- * CONNECTION : Through 6 core shielded cable provided along with the sensor of 2M length.
- * CALIBRATION JIG : Micrometer of 0 to 25mm length is mounted on the base.

PANEL DETAILS

DISPLAY	: $3\frac{1}{2}$ Digit LED display of 200mV FSD to read upto “+/- 1999” counts.
ZERO	: Single turn potentiometer to adjust “000” when the sensor is connected.
CAL	: Single turn potentiometer to adjust the calibration point.
CIRCUITRY	: Block diagram of the circuit for displacement indicator. The diagram also shows LVDT block diagram also.

L V D T WITH CALIBRATION JIG



MOUNTING OF L V D T ON THE CALIBRATION JIG

L V D T has to be mounted perfectly on the calibration Jig. Micrometer should be moved till the micrometer reads 20.0 mm. LVDT should be mounted too the center plate by the two nuts provided. The core of the LVDT should be aligned with the core of the micrometer. Adjust the core of the LVDT till it touches the micrometer core and tighten the nut.

CONNECTION DETAILS

CONNECTING INSTRUMENT TO MAINS

3 Pin power chord is provided, attached to the instrument. Connect the 3pin plug to 230V 50Hz. socket.

Before connecting ensure that the power On switch is in OFF position.

SENSOR CONNECTION

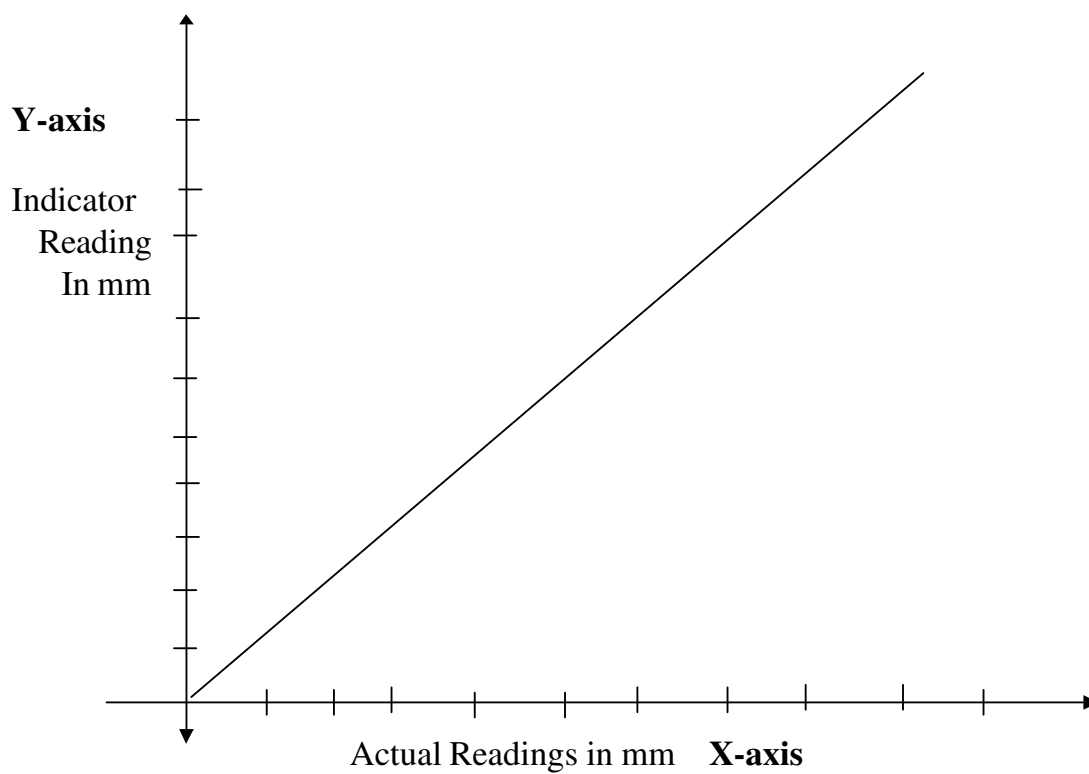
6 core shielded cable is connected to the LVDT with male connectors of different colors are fixed to each wire. Connect the male pins to the socket matching the color correctly.

OPERATING PROCEDURE

- 1 Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the instrument 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"
- 3 Adjust the CAL potentiometer at the front panel so that the display reads "10.0"
- 4 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 display read 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. Tabulate the readings and Plot the graph Actual V/s indicator reading.

[illegible]

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



RESULT:The given LVDT is calibrated.

STRAIN MEASUREMENT TRAINER

AIM : To calibrate the given strain measurement trianer.

APPARATUS: strain measurement trianer.

Introduction:

The primary object of the INSTRUMENTATION TRAINER is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure, torque, displacement, acceleration, frequency, etc. The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, and strength of materials or thermodynamics. The student's experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.

Emphasis in the instrumentation trainer will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately and completely characterize the design or process being experimentally evaluated. Also, the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend in instrumentation toward electronic methods.

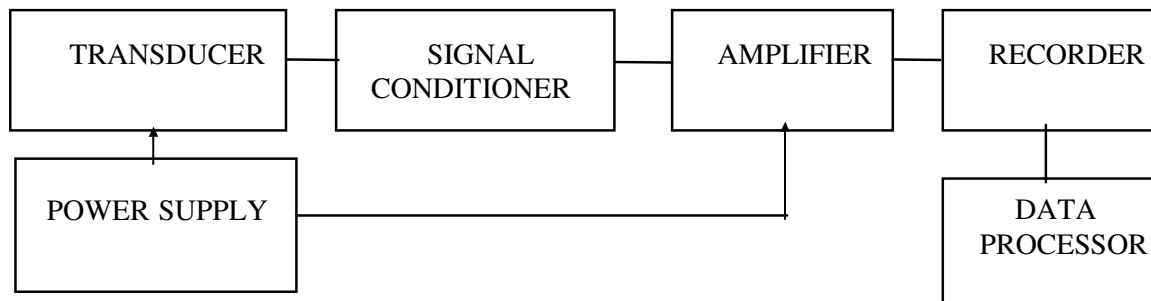
An attempt is made through these "Instrumentation trainer" to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that the block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self-explanatory and also the best teaching aid for Engineering students.

Since the instrumentation tutors are not instruments as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

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

THE INSTRUMENT

UNIQUE Digital Strain measuring setup comprises of Strain Indicator and Cantilever Beam setup. Strain Indicator is a strain gauge signal conditioner and amplifier used to measure strain due to load applied on the cantilever beam. The strain gauge are bonded on the cantilever beam and are connected in the form of whetstones bridge. A pan and weights upto 1Kg is provided to load the cantilever beam. Uniques Strain measuring setup is a complete system which can be used to conduct measurement on strain using strain gauges. The strain indicator is provided with zero balancing facility through adjustable potentiometer. Digital display will enable to take error free readings.

The digital indicator comprises of four parts.

1. Power Supply 2. Signal conditioning 3. Amplifier 4. Analog and digital converter.

The inbuilt regulated power supply used will provide sufficient power to electronic parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioners Buffers the output signals of the transducers. Amplifier will amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog out put to digital signals and display through LED's.

THEORY BEHIND IT

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 l So according to the definition strain S is given by

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

Since the change in the length of the material is very small it is difficult to measure l . So the strain is always read in terms of microstrain. 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 S_g where S_g is given as

$$\Delta R / R = S_g \dots\dots\dots \text{Eq 2}$$

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

The output $\Delta R / R$ of a strain gauge is usually converted into voltage signal with a Wheatstone bridge. If a single gauge is used in one arm of Wheatstone bridge and equal but fixed resistors are used in the other arms, the output voltage is

$$E_o = E_i / 4 (\Delta R / R_g) \dots\dots\dots \text{Eq 3}$$

Substituting Eq 2 into Eq 3 gives

$$E_o = 1/4 (E_i S_g \epsilon)$$

.....Eq 4

The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage E_o usually ranges between 1 to 10 mV / microstrain.

SPECIFICATION

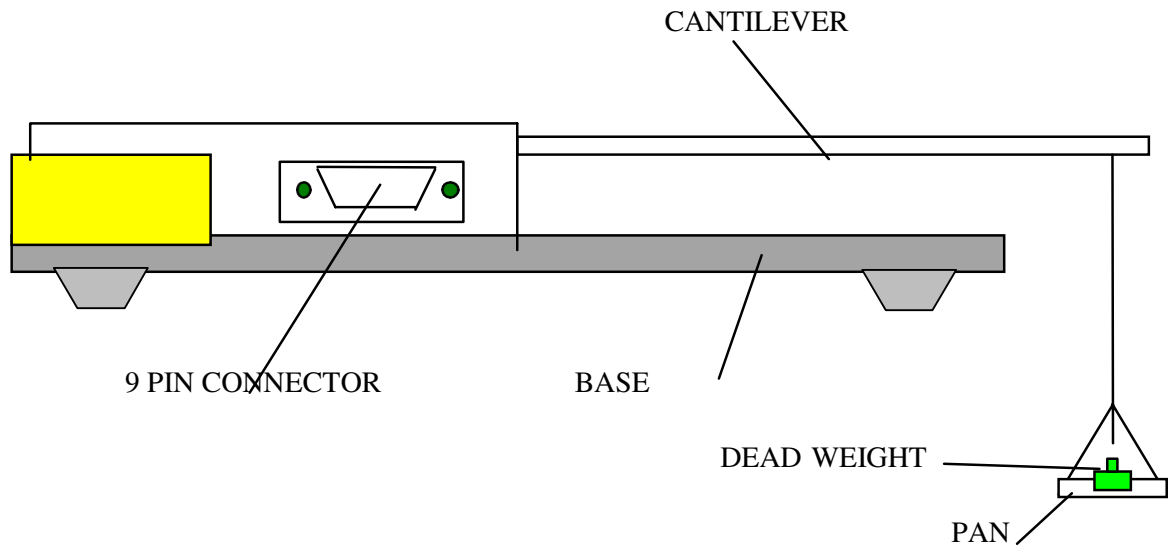
DISPLAY RANGE	: 3 1/2 digit RED LED display of 200 mV FSD to read up to +/-1999 microstrain .
GAUGE FACTOR SETTING	: 2.1
BALANCE	: Potentiometer to set zero on the panel.
BRIDGE EXCITATION	: 10V DC
BRIDGE CONFIGURATIONS	: Full Bridge.
MAX. LOAD	: 1Kg.
POWER	: 230 V +/- 10% at 50Hz. with perfect grounding.

All specifications nominal or typical at 23⁰ C unless noted.

All specifications nominal or typical at 23⁰ C unless noted.

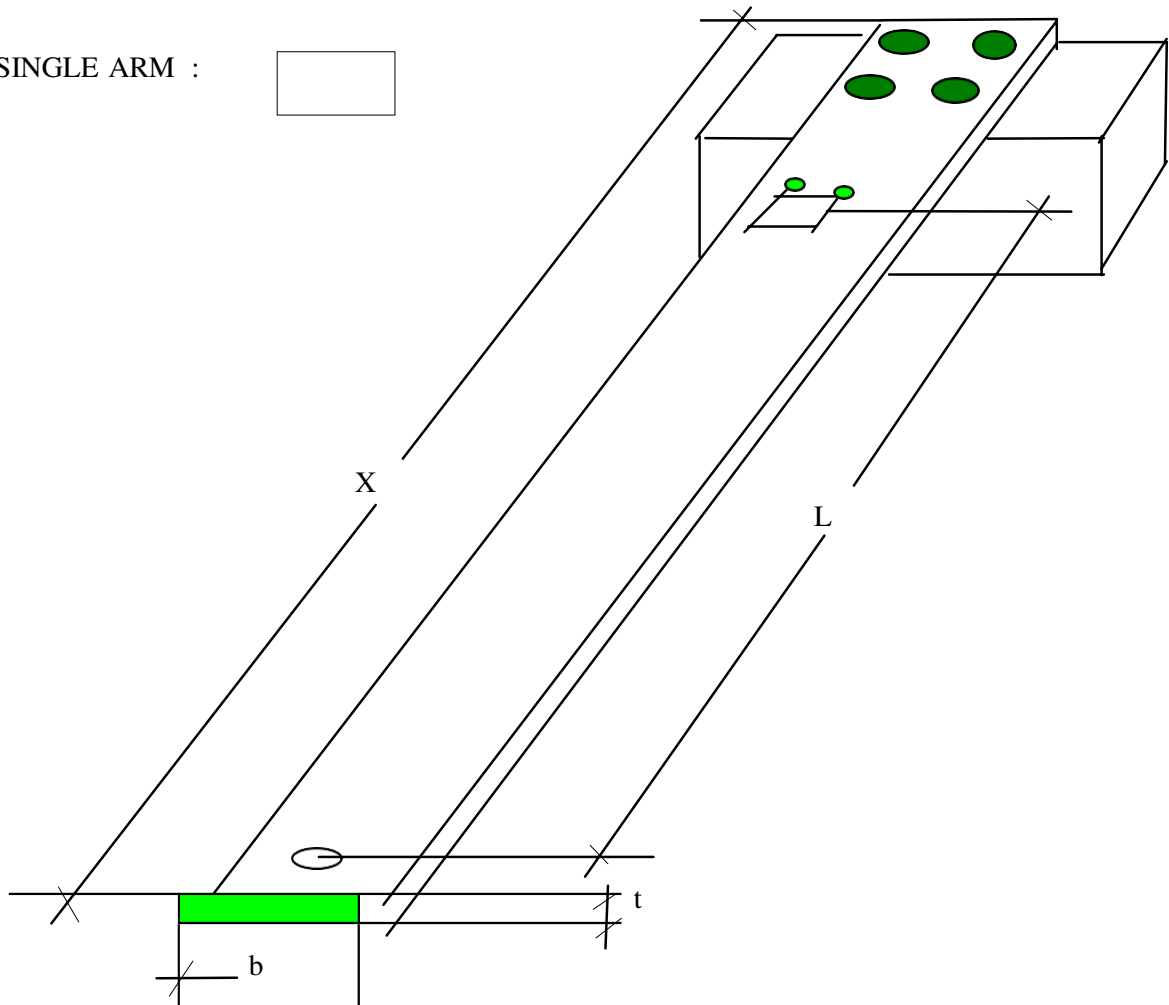
CANTILEVER BEAM SPECIFICATION

MATERIAL	: Stainless Steel
BEAM THICKNESS (t)	: 0.25 Cm
. BEAM WIDTH (b)	: 2.8 Cms.
BEAM LENGTH (Actual)	: 22 Cms.
YOUNGS MODULUS (ϵ)	: 2×10^6 Kg / cm ² .
STRAIN GAUGE	: Foil type gauge
GAUGE LENGTH (l)	: 5 mm
GAUGE RESISTANCE (R)	: 300 Ohms.
GAUGE FACTOR (g)	: 2.01

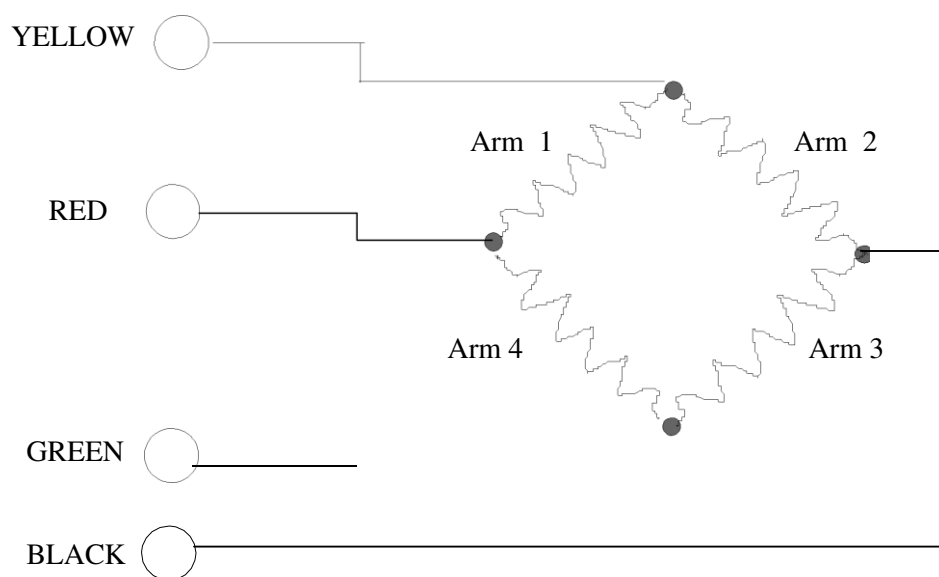
CANTILEVER BEAM SETUP

PHYSICAL DIMENSION OF THE CANTILEVER BEAM

SINGLE ARM :

**PHYSICAL DIMENSIONS**

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

CONNECTION DETAILS

OPERATING PROCEDURE

- 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.
- Allow the instrument in ON Position for 10 minutes for initial warm-up.
- Adjust the ZERO Potentiometer on the panel till the display reads „000“.
- Apply 1 Kg load on the cantilever beam and adjust the CAL potentiometer till the display reads 377 micro strain. (as per calculations given below) Remove the weights the display should come to ZERO in case of any variation adjust the ZERO pot again and repeat the procedure again. Now the Instrument is calibrated to read micro-strain.
- Apply load on the sensor using the loading arrangement provided in steps of 100g upto 1Kg.
- The instrument displays exact microstrain strained by the cantilever beam
- 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.

Specimen calculation for cantilever beam

$$S = (6 P L) / B T^2 E$$

P = Load applied in Kg. (1 Kg)

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

B = Width of the beam (2.8 Cms)

T = Thickness of the beam (0.25Cm)

E = Youngs modulus (2×10^6)

S = Microstrain

Then the microstrain for the above can be calculated as follows

$$S = \frac{6 \times 1 \times 22}{2.8 \times 0.25^2 \times (2 \times 10^6)}$$

$$S = 3.77 \times 10^{-4}$$

$$S = 377 \text{ microstrain.}$$

Sample Readings:

A SL. No.	B Weight (in grams)	C Actual readings (using formulae) $S = (6 P L) / B T^2 E$ (in micro strains)	D Indicator readings (in micro strains)	E ERROR in %

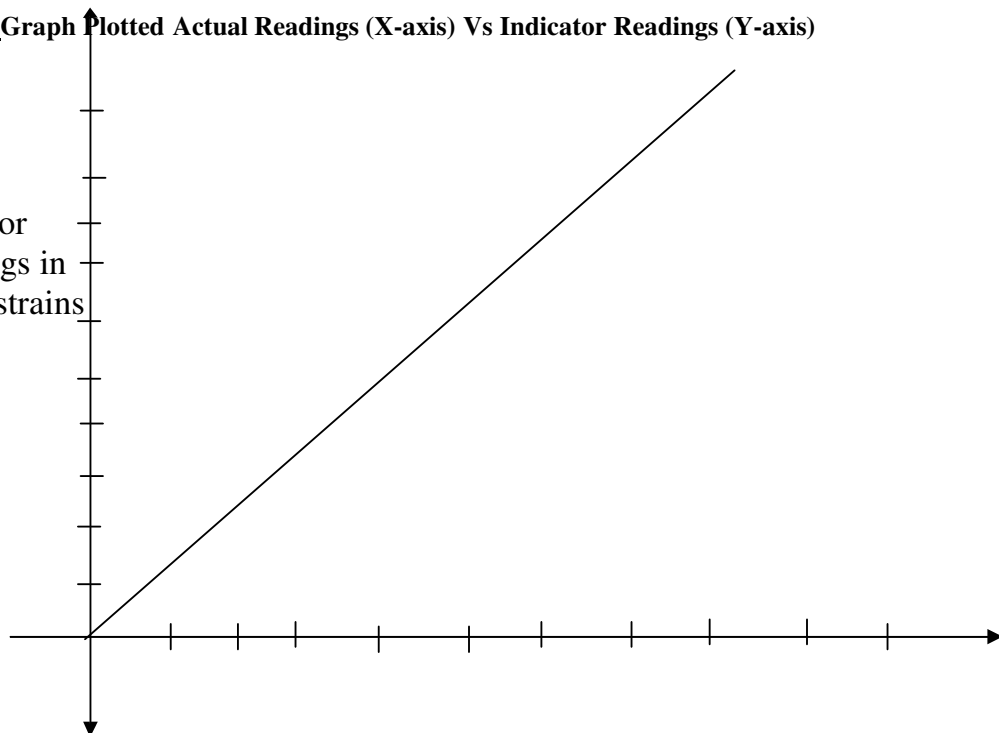
$$\% \text{ ERROR} = \frac{[(\text{Actual Reading (C)} - \text{Indicator Readings (D)}) \times 100]}{\text{Max. Weight in gms}}$$

RESULT: the given strain measurement gauge is calibrated.

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

Y-axis

Indicator
Readings in
Micro strains



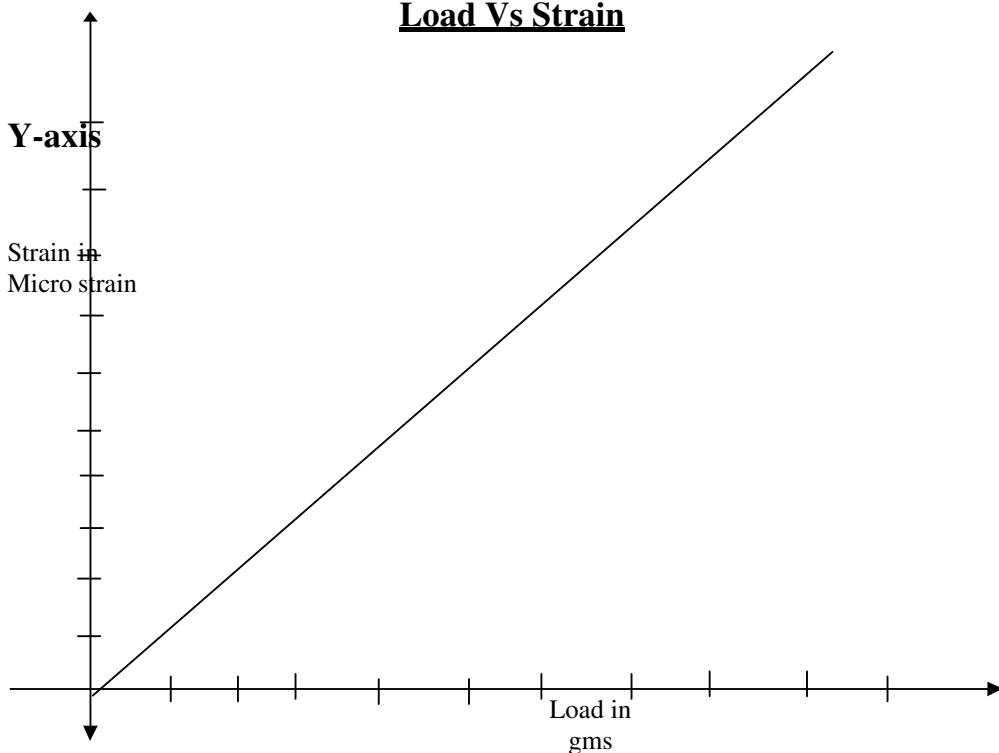
X-axis

38 75 113 150 187 224 260 297 336 377
Actual Reading in micro strains

Load Vs Strain

Y-axis

Strain in
Micro strain



X-axis

TEMPERATURE CALIBRATER USING 'K' TYPE THERMOCOUPLE

AIM : to calibrate temperature calibrator using thermocouple „K“ type thermocouple

APPARATUS: temperature calibrator using „K“ type thermocouple

INTRODUCTION

The New-Tech Temperature Calibrator for Calibret of Temperature Thermocouple „K“ type. The Tutor is very useful for study of temperature through „K“ type Thermocouple sensor. The circuit diagram is given on the top cover on the tutor to understand the measurement parameter at a glance. All the different test point are also provided on top cover with giving their headings to facilitate the student to understand without any operation instruction by any third person.

Thermocouple Range	:	100°
Resolution	:	0.1°
Analogue output	:	2 Volts DC

Top Panel :

1.	Display	:	3-1/2 digit LED
2.	Inputs	:	Thermocouple sensor („K“ type)
3.	Zero pot	:	Provided for zero adjustment
4.	Span pot	:	Provided for calibration.
5.	ON/OFF switch	:	To ON/OFF the system.,
6.	Fuse	:	0.5 milliamps.
7.	Light LED	:	Indicates the power supply when the when is in 'ON' position.
8.	Test point +/- 5V	:	a) Display card supply
			There are three terminals
			Red : + 5V
			Green :
	Common		Black : - 5 V

b) Thermocouple Signal conditioner

card supply +/- 12V

There are three terminals

for :

Red : + 12 V

Green :

Common

Black : - 12 V

d) Sensor input point

When the system is in OFF position you can measure the resistance of Sensor.

ALL THE TEST POINT CAN BE MEASURED THROUGH MULTIMETER AND CRO.

OPERATING PROCEDURE

1. To connect the T/C sensor at the 9 pin connector.
2. Switch 'ON' the system the power indicator. The RED LED on the front panel will glow.
3. Give the 0°C temperature to the T/C by keeping it into the Ice, adjust the 000 reading on the display by adjust through Zero Pot.
4. Keep the T/C into the boiling water and adjust the display reading 100 by adjusting through Span Pot 100oC is calibrated.
5. Keep the T/C in room temperature. The Indicator will display room temperature.

PRECAUTIONS

- ◆ To get the good performance from the Tutor you have to maintain room temperature.
- ◆ To check the power source, it should be 230V +/-10%, 50 Hz. to avoid over voltage hazards.
- ◆ To get best performance, you have to put the instrument at dust proof and humidity free environment.

- ♦ Do not try to open the instrument or repair it. Contact manufacturer in case of any fault/difficulty.

Control Pots :

- 0°C (IC point) adjust by zero trimpot.
- 100° C (Boiling point) adjust by span trimpot

Observation Table :

	Temperature	play reading °C	Analogue output Volts	mV 'K' type T/c
	00°	00	0.0 Volts	
	10°			
	20°			
	30°			
	40°			
	60°			
	80°			
	100° measure with 1 boiling point)			

RESULT: The given k type thermocouple gauge is calibrated

DEAD WEIGHT PRESSURE GAUGE TESTER (FOR PRESSURE CALIBRATION)

AIM : To calibrate given pressure gauge.

apparatus: dead weight pressure gauge tester

An external force may define pressure as the force executed on a unit area of a fluid or any other substance. If „F” represents the total force uniformly distributed over an area “A” then pressure at any point is $P=F/A$. However if the force is not uniform the magnitude of pressure at any point can be obtained from

$$P = \frac{dF}{dA}$$

dF^1 : Force acting on an infinitesim area dA

Units : SI units :

Metric gravitational units : KgF/cm^2 or $\text{Kg(F)}/\text{m}^2$

Absolute Pressure : Pressure exerted by earths gravitation as commonly measured by barometer. It varies with attitude.

Gauge Pressure : When pressure is measured either above or below atmospheric pressure at datum then it is called gauge pressure. This is because practically all pressure gauges read zero when open to atmospheric and read only the difference between the pressure of fluid and atmosphere.

Differential pressure : The difference between two measured pressures such as on inlet and outlet process line is called differential pressure.

Vacuum : If the pressure of a fluid is below atmospheric pressure, it is designated as vacuum or nagative gauge pressure.

Static Pressure : The force per unit area acting on a wall by a fluid at rest is called static pressure.

Hydrostatic Pressure : Pressure at a point below a liquid above it is called head.

Pascal's Law : Pressure at any point in a fluid at rest has the same magnitude in all directions.

In other words when a certain pressure is applied at any point in a fluid at rest, the pressure is equally transmitted in all directions.

To calibrate the given pressure gauge and plot the graph of

(a) % error v/s reading (Pressure gauge reading)= MR

(b) % Actual reading v/s meter reading

MR = Pressure shown by the gauge

AR = Actual pressure reading = W/A

A = Area of plunger in m^2

W = Total weight in Kg

Procedure :

1. Dead weight pressure gauge testes should be checked for oil level. Fill the oil if level is less.
2. Check the level by tightening screw rod & opening the valve completely in the drain side. After checking close the valve and release the screw rod.

3. Apply full load on the plunger(which includes plunger weight). Remove one by one as indicated below .

0.13Kg = plunger weight

5.64Kg = Total weight 8 weights + plunger weights (Nos : 1 to 8) Full load

5.5Kg = weight of 7 weights (Nos : 1 to 7) Remove 8

5.2Kg = weight of 6 weights (Nos : 1 to 6) Remove 7

4.67Kg = weight of 5 weights (Nos : 1 to 5) Remove 6

4.11Kg = weight of 4 weights (Nos : 1 to 4) Remove 5

3.55Kg = weight of 3 weights (Nos : 1 to 3) Remove 4

2.99Kg = weight of 2 weights (Nos : 1 to 2) Remove 3

1.53Kg = weight of 1 weight (Nos : 1) Remove 2

4. Rotate the screw rod till the plunger lifts & gauge reads maximum
5. Now note down the pressure gauge reading (MR) & total weight (AR) in the table given. Calculate A and AR.
6. For each load note down meter reading.
7. Repeat the same procedure for points 4 and 5 by decreasing each weight & note down readings directly. Calculate percentage error as given by using equations.
8. Release the screw rod completely before taking out all the weights.
9. Plot the graphs

% error v/s AR

AR v/s MR

On the same graph sheet

Weight of the plunger = 0.13 Kg

Diameter of the plunger = 0.6 cm

Weight on plunger including plunger weight in KG ,W	Pressure gauge reading inKg/cm2 MR	Actual pressure on the plunger in Kg/cm2 AR	Percentage error AR-MR/AR*100

RESULT: The given pressure gauge is calibrated.

SPEED MEASUREMENT TRAINER

Measurement of speed using Magnetic pickup

AIM: To calculate vibration using seismic transducer

APPARATUS: speed measurement trainer

INTRODUCTION:

The primary object of the INSTRUMENTATION TUTORS is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure, torque, displacement, acceleration, frequency, etc. The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, strength of materials or thermodynamics. The student's experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.

Emphasis in the instrumentation tutor will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately and completely characterize the design or process being experimentally evaluated. Also, the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantages of the electronic measurement system over the mechanical measurement system have initiated and sustained trend in instrumentation toward electronic methods.

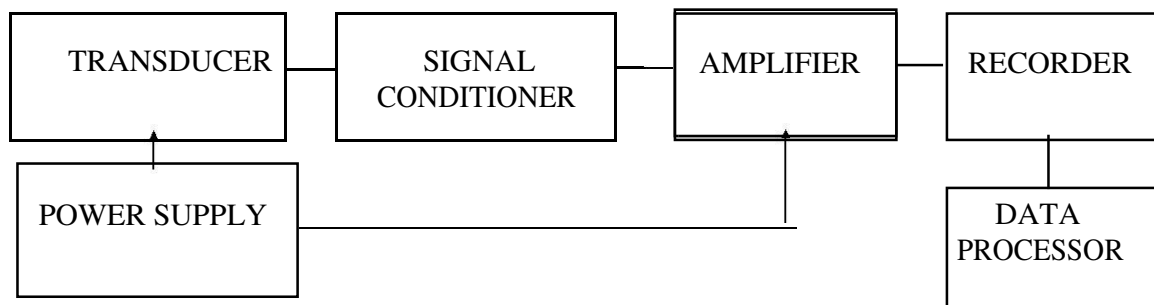
An attempt is made through these "Instrumentation tutors" to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that the block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self-explanatory and also the best teaching aid for Engineering students.

Since the instrumentation tutors are not instruments as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.

The **TRANSDUCER** is a device that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



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

SIGNAL CONDITIONERS are electronic circuits that convert, compensate, or manipulate the out put from in to a more usable electronic quantity. Example the wheat stone bridge used in the strain transducer converts the change in resistance R to a change in the resistance E

AMPLIFIERS are required in the system when the voltage out put from the transducer signal conditioner combination is small. Amplifiers with gains of 10 to 1000 are used to increase their signals 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 form that 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 into data that can be easily interpreted by the Engineer . Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

CIRCUIT EXPLANATION

The circuit comprises of mainly five parts such as

1. Power Supply,
2. Oscillator
3. Signal conditioner,
4. Mixerand
5. Counter.

1. POWER SUPPLY

The power supply required for speed measurement is regulated 6V, 250mA DC supply. This 6V is used for both signal conditioner and also to drive the display.

2. OSCILLATOR

Quartz crystal is used to generate oscillating frequency. The crystal Oscillator uses 5V dc and produces an oscillating frequency of 1khz. An amplifier is used to amplify the signal to the required level.

3. SIGNAL CONDITIONER

The signal conditioner gets the input from the sensors in the form of pulses. For every one revolution 60 pulses are produced. These pulses are then amplified to the required level when the calibration is done. These signals are buffered to get pure oscillating frequency.

4. MIXER

The mixer combines the input signal from the sensor with the oscillating frequency. This produces sum-and-difference components. When mixed, a third pulse is produced. The frequency of the pulse is a function of the difference in the two original inputs. If the frequency of one of the source is known and is adjusted to produce zero pulse, then the frequency of the other source is also known by comparison. This procedure for determining frequency is called the heterodyne method. The two signals are heterodyned.

5. COUNTER

The multiplexer converts the frequency into a simple voltage pulses. Electronic counter uses basic counting device or Event per unit Time meters require that the counted input be converted into a simple voltage pulses, a count being recorded for each pulse. The pulses are counted and displayed through seven segment LED's.

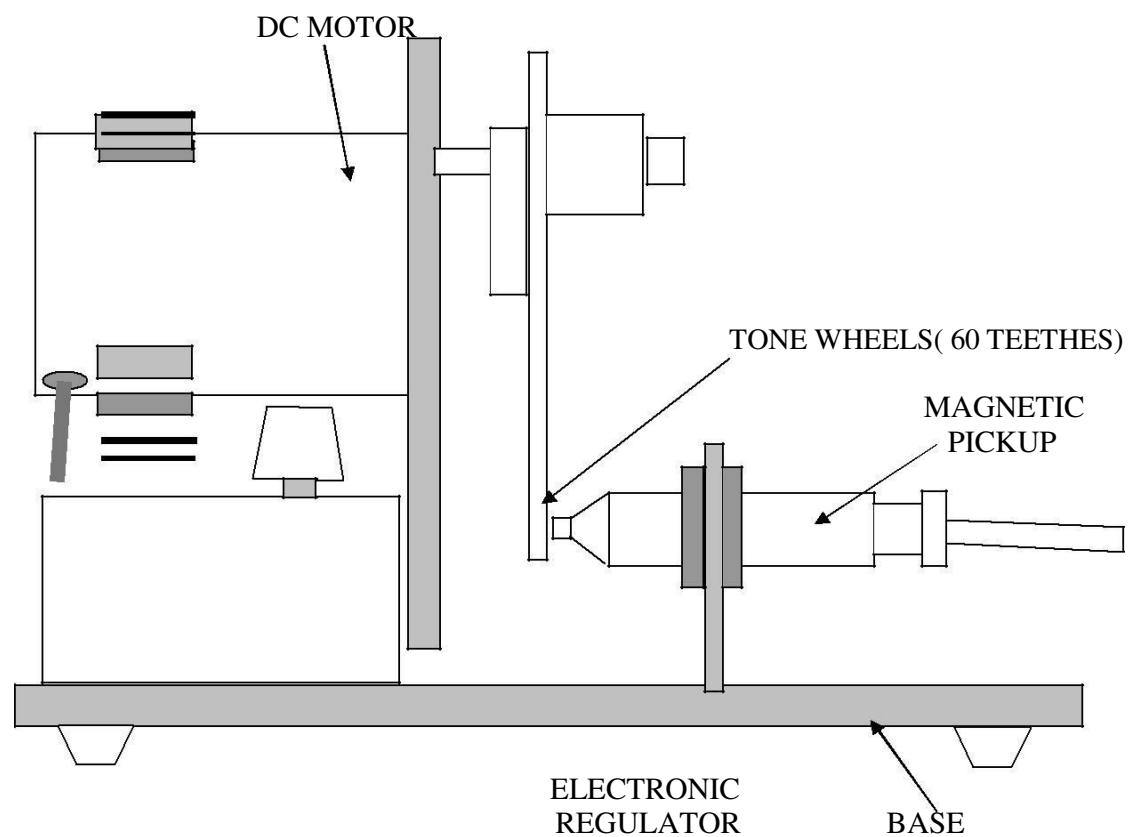
SPECIFICATION

MEASUREMENT OF SPEED

SENSOR	: a) Magnetic Pickup
MAX. RPM	: 1500 RPM
MOTOR	: FHP DC motor to rotate at 1500 RPM
MOTOR SPEED CONTROL	: 0-12V variable DC Drive.
TONE WHEELS	: a) For magnetic pickup : MS wheel of 2 mm thick disk, on the circumference 60 teethes will be cut at equidistant.
POWER	: The instrument works at 230V 50Hz. supply.

PANEL DETAILS

- DISPLAY : 4 Digit seven segment LED display to display upto "9999" counts.
- 3 PIN SOCKETS : To connect magnetic pickup sensor
- THE CIRCUITRY : The circuitry is only a block diagram of the speed indicator with various test points provided to test while experiment for the easy understanding various stages of the speed indicator.



MOUNTING ARRANGEMENT OF SPEED MEASUREMENT SETUP

CONNECTING DETAILS

CONNECTING INSTRUMENT TO MAINS

The 3-pin power chord is fixed to the instrument. Plug the chord to 230V 50Hz. mains.

CONNECTING SENSORS

The magnetic pickup mounted on the speed setup. Connect the sensor to the three pin connector provided on the panel.

OPERATING PROCEDURE

Before switching ON the instrument ensure that the connections are made properly.

Switch ON the instrument by pushing down the toggle switch provided at the rear side of the box, LED display glows to indicate the instrument is ON.

Allow the instrument for 10 minutes in ON position for initial warm-up.

Switch on the regulator. The motor rotates which will rotate the tone wheels. The display will start indicating exact RPM of the motor.

RESULT: The given speed measurement device is calibrated.

VIBRATION BY USING SEISMIC TRANSDUCER IN ENGINE TEST BED

AIM:

Calculation of vibration by using seismic transducer in engine test bed

APPARATUS: seismic transducer

DESCRIPTION:

Motor is connected to a cam 1mm excentric by varying the knob speed of motor changes the displacement on the follower will be measured by using seismic pick up transducer (amplitude). Which will be noted in the digital display and tabulated

Vibration seismic pickup can be placed where ever vibration has to be measured on engine test bed.

PROCEDURE:

1. Switch on the mains and wait until vibration meter shows zero
2. Slowly increase the speed of motor by using knob
3. Note down the reading in the vibration meter.
4. Repeat the experiment for different speeds.

RESULT: The given seismic transducer is calibrated.

PRESSURE MEASUREMENT INSTRUMENTATION TUTOR

AIM: To calibrate the given pressure Pressure Sensor Strain Gauge

APPARATUS: pressure measurement instrumentation tutor

INTRODUCTION:

INTRODUCTION

The Instrumentation Tutor is meant for measurement of pressure through Strain Gauge Based Sensor. The Tutor is very useful for study of pressure through Pressure Cell. The circuit diagram is given on the top cover on the tutor to understand the measurement parameter at a glance. All the different test points are also provided on top cover with giving their headings to facilitate the student to understand without any operation instruction by any third person.

Range	:	10 kg/m ²
Resolution	:	0.1 kg/cm ²
Display	:	3-1/2 digit
Excitation	:	5.00 Volt, DC
Analog Output	:	2 Volt, DC
Power source	:	230 V +/-10%, 50 HZ

Top Panel :

1.	Display	:	3-1/2 digit LED
2.	Inputs	:	Pressure Sensor Strain Gauge Based
3.	Cal Check	:	On pushing the red switch you will observe the adjusted calibration on the display.
4.	Zero pot	:	Provided for zero adjustment
5.	Span pot	:	Provided for calibration.
6.	ON/OFF switch	:	To ON/OFF the system.,

7. Fuse : 0.5 milliamps.
8. Light LED : Indicates the power supply when the when is in 'ON' position.

9. Test point : **a) Display card supply +/- 5V**
 There are three terminals :
 Red : +5V
 Green : Common
 Black : -5V

b) Pressure Cell Signal conditioner card

supply +/-12V

There are three terminals for :

- Red : +12V
 Green : Common
 Black : -12V

c) Analogue output 2V full range of pressure cell.

- Red : High
 Green : Low

d) Pressure Cell full bridge

When the system is in OFF position the RED and Green points are for Excitation 350 ohms.

The Yellow and Black pints are for Signal 350 ohms.

When the system is in ON position,

- Red : E+
 Green : E-
 Excitation : 5V fixed.
 Signals :
 Yellow : +
 Black : -

Signal maximum pressure 10 kg/cm²
 _____mV

ALL THE TEST POINT CAN BE MEASURED THROUGH MULTIMETER AND/OR CRO.

OPERATING PROCEDURE

1. To connect the Pressure Cell at the 9 pin connector.
2. Power 'ON' the switch. The front RED LED glow with which indicates the power available on the instrument.
3. Give some time to stabilize the instrument for stabilization (warm up time).
4. Balancing the Pressure Cell by through the corresponding "ZERO" ten turn timpot.
5. Set the gain of Pressure cell by "SPAN" ten turn trimpot.
6. Then to push the micros witch to ascertain the reading position of CAL. The present CAL position in the instrument is_____.
7. For example :

To apply the Pressure on Pressure Cell say 10 kg/cm^2 . You will observe some reading on the display say something like 9.6 or so. Now you have to adjust this reading say 10.0 by rotating the Span pot and to stop rotating with the desired 10.0 counts are visible.

PRECAUTIONS

- To get the good performance from the Tutor you have to maintain room temperature.
- To check the power source, it should be 230V +/-10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it. Contact manufacturer in case of any fault/difficulty.

Control pots :

- Zero adjust for trimpot
- Span adjust for trimpot
- Excitation : 5.00 Volt, DC
- Cal Check : _____

Observation Table :

S. No.	Pressure applied kg/cm ²	Display Kg/cm ²	Reading Signal mV	Output Volts
1.	No pressure	0.0 kg/cm ²	0.0mV	0.0 V
2.	2 kg/cm ²			
3.	4 kg/cm ²			
4.	6 kg/cm ²			
5.	8 kg/cm ²			
6.	10 kg/cm ²			

RESULT: The given pressure Pressure Sensor Strain Gauge is calibrated.

**FUNCTIONAL BLOCK DIAGRAM OF
DIGITAL PRESSURE MEASUREMENT TUTOR**