Indira Gandhi Institute of Technology

Guru Gobind Singh Indraprastha University

Kashmere Gate, Delhi

Lab Manual

For

Metrology Lab

Indira Gandhi Institute of Technology

Mechanical & Automation Engineering Department

<u>Metrology Laboratory</u>

LIST OF EXPERIMENTS

The following experiments are to be conducted in the Sixth Semester in Engineering Metrology Laboratory:

1. A study of the linear and angular Measuring Instruments in the Metrology Lab.

2. To determine the outer and inner diameter of a hollow cylindrical work piece with the help of a Vernier Caliper.

3. To determine the diameter of a cylindrical wire using an Outside Micrometer.

4. To determine the height of a given work piece with the help of a Vernier Height Gauge.

5. To find the angle of the given wedge shaped work piece with the help of a Bevel Protractor.

6. To measure the angle of the given wedge shaped component with the help of a Sine Bar.

7. Leveling of a Surface Plate with the help of a Precision Spirit Level.

8. To compare the height of a given cylindrical work piece with the help of a Dial Gauge Indicator.

9. To check and compare the bores of given hollow cylindrical components with the help of a Dial Bore Gauge.

M.A.E DEPARTMENT (I.G.I.T)
METROLOGY LAB

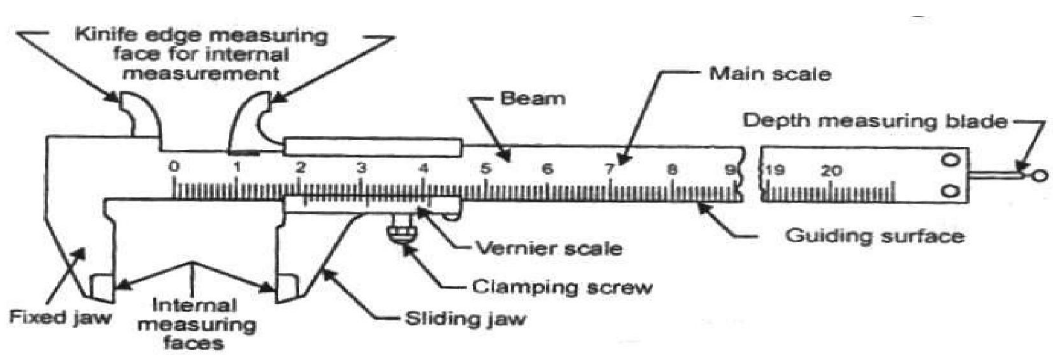
EXPERIMENT NO. 01

AIM: A study of the linear and angular Measuring Instruments in the Metrology Laboratory.

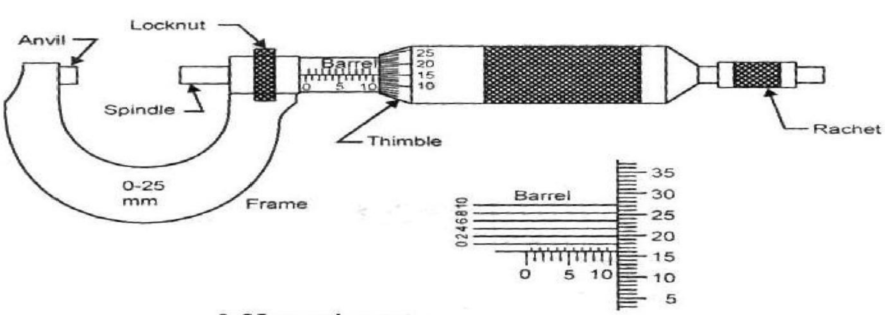
APPARATUS: Different measuring instruments used in metrology laboratory like vernier caliper, micrometer, vernier height gauge,bevel protractor,sine bar etc.

Different measuring instruments used in metrology laboratory are discussed for the purpose of study as follows:

(1.) Vernier Caliper :
The vernier caliper is primarily intended for linear measurement. The least count of the instrument depends upon the number of divisions on vernier scale and the number of divisions on main scale in that much length of main scale . For measuring both inside and outside diameter of a shaft, different jaws of vernier caliper may be used.Height and depth can also be measured with the help of depth measuring blade.



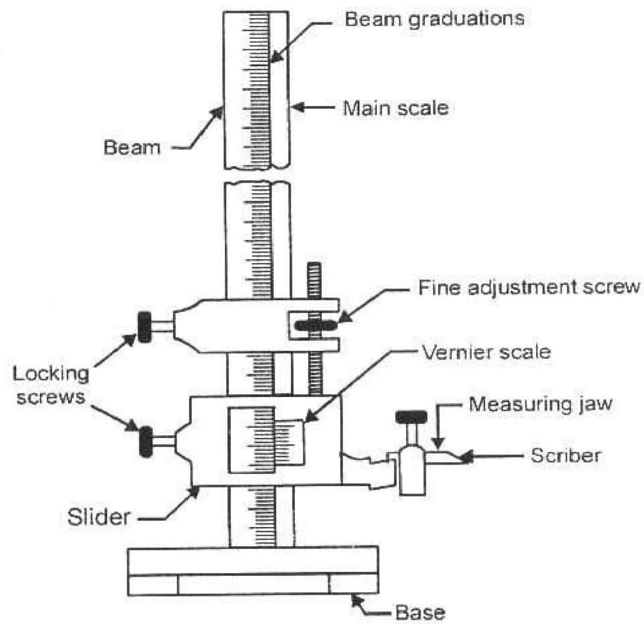
(2.) Micometer:
The micrometer is primarily intended for linear measurements. Micrometers of different types are used for measuring outer diameter and inner diameter. The micrometer works on the principle of screw and nut. When a screw is rotated through a nut by one revolution, it advances a distance equal to one pitch. The thimble is rotated till the spindle touches the work piece.The final adjustment is made by using ratchet. The locknut is then tightened and the dimension is measured on main scale & thimble scale.



0–25 mm micrometer.

(3.) Vernier Height Gauge :

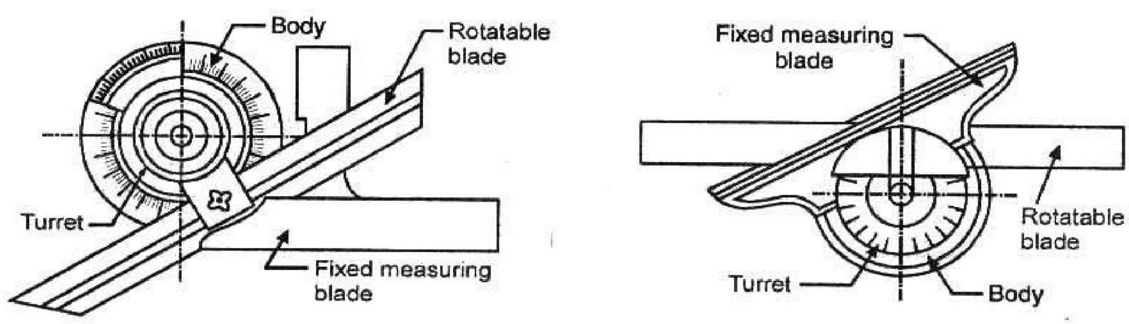
The working principle of a vernier height gauge is similar to a vernier caliper. A vernier height gauge is a sort of vernier caliper equipped with a special base block and other attachments which make it suitable for height measurements.



Height gauge.

(4.) Bevel Protractor :

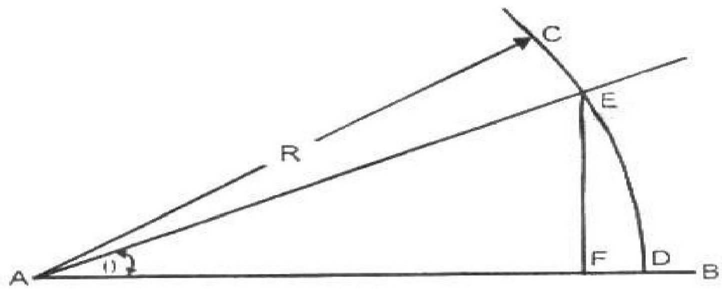
Bevel Protractor is used for measuring the angle between two faces of a component. It consists of a base plate attached to the main body and an adjustable blade to a circular plate containing vernier scale. A bevel protractor can be used to measure angles ranging from 0 to 360 degrees.



Vernier bevel protractor.

(5.) Sine Bar :

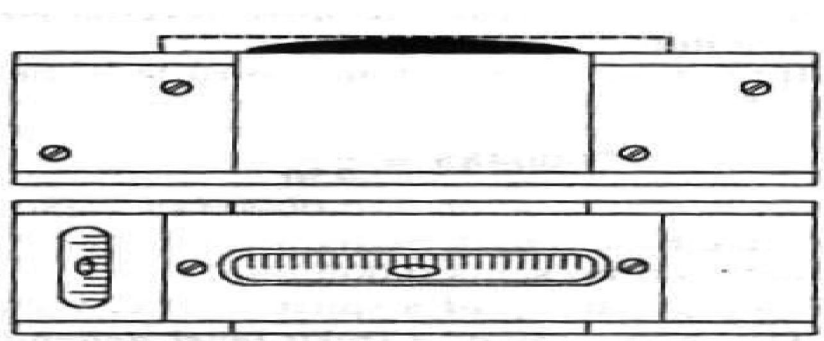
A Sine Bar is an instrument which in conjunction with slip gauges, can be used for precise measurement of angles and also for locating any work to a given angle within very close limits. The figure below shows the principle of sine bar. If we wish to set out any angle θ, we can do so by setting off a horizontal line AB, next scribing an arc CD with a measured radius R and then setting out a vertical dimension EF= R sin θ. This is quite easily done by means of the sine bar.



Principle of sine bar.

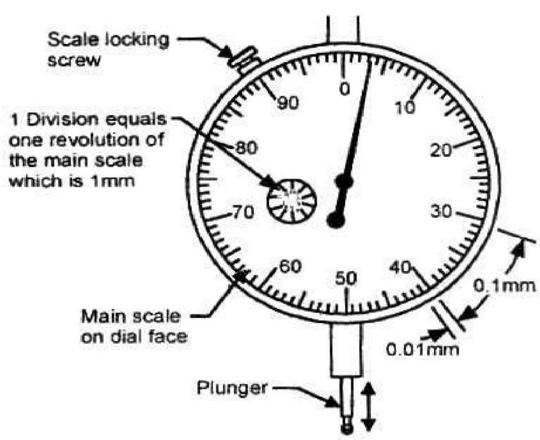
(6.) Precision Spirit Level :

Spirit Levels are used for measuring small angles or inclinations and also enable to check the level/position of a surface to be determined with respect to the horizontal.

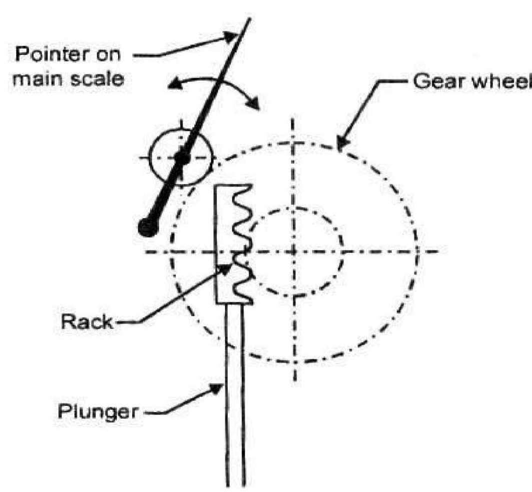

Block spirit level.

(7.) Dial Gauge Indicator :

A Dial Gauge Indicator is a type of mechanical comparator. The important and essential function of the instrument is to magnify or amplify the small input displacement so that it is displayed on an analogue scale. It detects and displays the small difference between the unknown linear dimension and length of the given standard. The difference in lengths is detected as a displacement of a sensing probe and displayed on the dial scale.



Dial indicator.



Principle of operation of a dial indicator.

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FOR

A Study of the Linear and Angular Measuring Instruments in the Metrology Laboratory

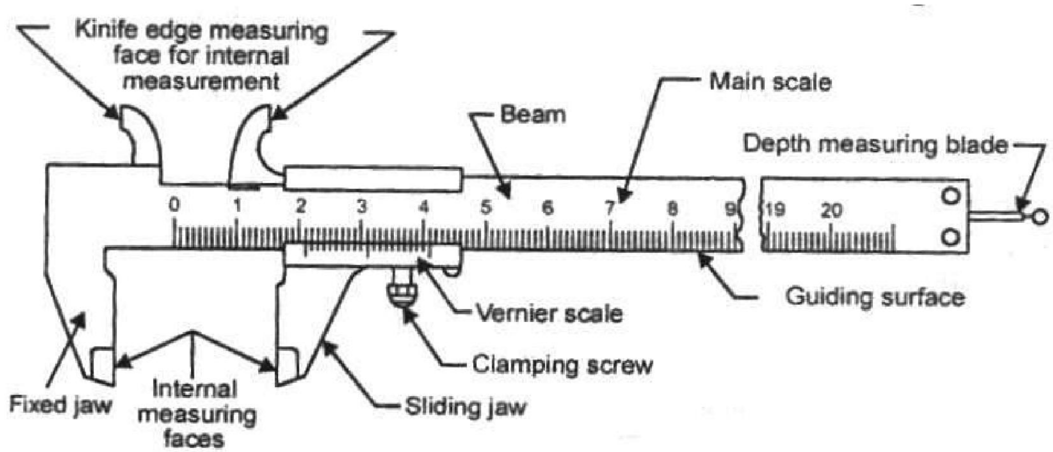
EXPERIMENT NO. 02

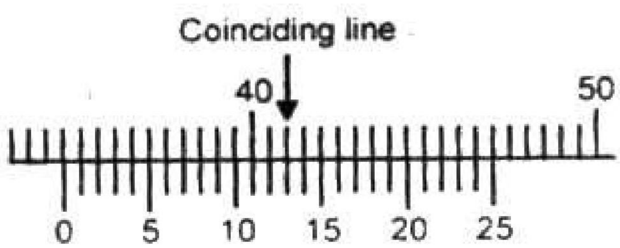
AIM: To determine the outside and inside diameter of hollow cylindrical workpieces with the help of vernier caliper.

APPARATUS: Vernier caliper, workpieces.

THEORY: The vernier caliper is primarily intended for linear measurement. The least count of the instrument depends upon the number of divisions on vernier scale and the number of divisions on main scale in that much length of main scale . For measuring both inside and outside diameter of a shaft, different jaws of vernier caliper may be used. The movable jaw assembly is so adjusted that the two measuring jaws just touch the work piece to be measured. Then the lock nut is tightened. Final adjustment depends upon the sense of the correct feel. After final adjustment has been made, the other locking nut is also tightened & the reading is taken.

Construction:





A Vernier Caliper consists of two scales. Fixed scale is called as a **main scale** & it is calibrated on Lshaped **frame**, which carries a **fixed jaw**. The movable scale is called as **vernier scale** & it slides over the main scale, which carries **movable jaw**. When the two measuring jaws are in contact with each other, the scale should show zero reading. Jaws for internal measurements have **knife edge measuring faces**. It also has a **depth measuring balde** for measurement of depth of blind holes/slots. An **adjustable screw** is provided for fine adjustment of movable jaw. Also, a **clamping screw** is provided to lock the sliding scale on main scale.

PROCEDURE:

1. Clean the workpiece and instrument.
2. Check the vernier caliper for errors like play in the jaw, zero error if any.
3. If any error is present, correct it.
4. Calculate the least count of the instrument.
5. Hold the workpiece in the measuring jaws.
6. Note down the readings on main scale & vernier scale.
7. Take the measurements for at least 3 components by vernier caliper.
8. Calculate the total reading of vernier caliper.
9. Complete the observation table.

OBSERVATION TABLE:

Measurements taken using Vernier Caliper:

Sr. No.	Reading on Main Scale (MSR)	Reading on Vernier Scale (VSR)	Total Reading = MSR+ (LC*VSR)
1.			
2.			
3.			
4.			
5.			

Result:

Write the name of components and their measured dimensions.

Precautions:

1. There should not be any play between sliding jaw & the main scale.
2. Check the instruments for zero error.
3. Parallax or reading error must be avoided.
4. Do not apply undue pressure.

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FOR

Determining the Outside and Inside Diameter of Hollow Cylindrical Workpieces with the help of **Vernier Caliper**

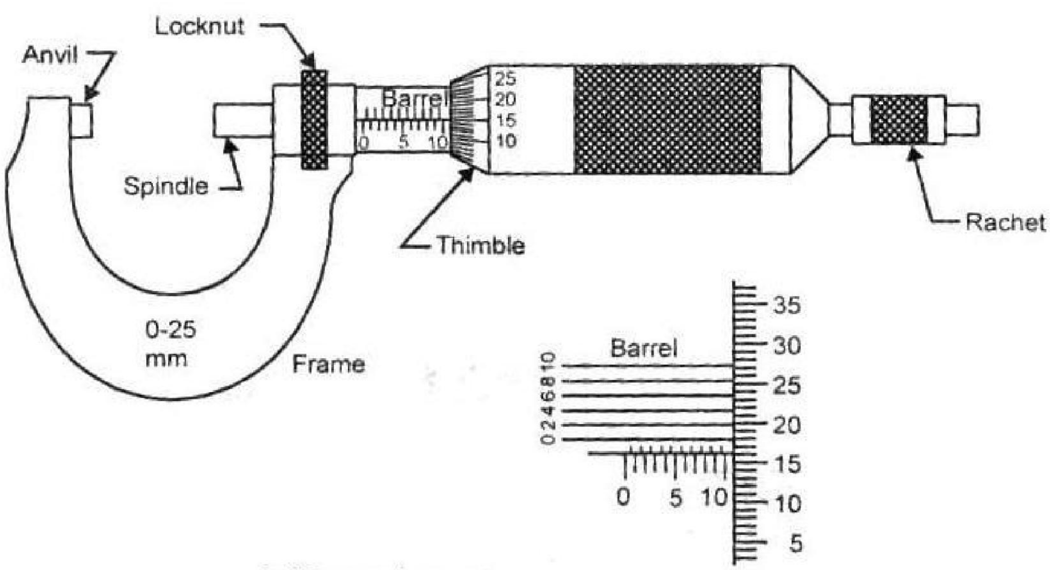
EXPERIMENT NO. 03

AIM : To determine diameter of cylindrical wire by using an outside micrometer.

APPARATUS : Outside Micrometer, Workpieces.

THEORY : The micrometer is primarily intended for linear measurements. The micrometer works on the principle of screw and nut. When a screw is rotated through a nut by one revolution, it advances a distance equal to one pitch. The thimble is rotated till the spindle touches the work piece.The final adjustment is made by using ratchet. The locknut is then tightened and the dimension is measured on main scale and thimble scale.

Construction:



0–25 mm micrometer.

A micromer consists of a screw having 10 or 20 threads per cm and revolves in a fixed nut. The end of the screw forms one measuring anvil and a fixed anvil is in the frame. The spindle can be advanced or retracted by rotating the thimble. Barrel is a fixed part attached with the frame. The spindle is slide fit in the barrel. Generally, the pitch of screw thread is 0.5 mm & the thimble has 50 equal divisions on the circumference. Ratchet is provided at the end of thimble to apply sufficient and uniform measuring pressure.

PROCEDURE:
1. Clean the workpiece and instrument.
2. Check the micrometer for errors like play in the anvil, zero error if any.
3. If any error is present, correct it.
4. Calculate the least count of the instrument.
5. Hold the workpiece in the measuring anvils or firmly in a hand.
6. Note down the readings on main scale, thimble scale/vernier scale.
7. Take the measurements for at least 3 components by micrometer.
8. Calculate the total reading of micrometer.
9. Complete the observation table.

OBSERVATION TABLE:
Measurements taken using Out Side Micrometer:

Sr. No.	Reading on Main Scale (MSR)	Reading on Vernier Scale (VSR)	Total Reading = MSR+ (LC*VSR)
1.			
2.			
3.			
4.			
5.			

Result:
Write the name of components and their measured dimensions.

Precautions:
1. Clean the measuring surface of anvil before use.
2. Check the instrument for zero reading before use.
3. While taking measurements, pressure applied on thimble must be correct. Use ratchet for final judgment of pressure.
4. Do not apply undue pressure.
5. Parallax or reading error must be avoided.

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FOR

Determining the Diameter of Cylindrical Wire by using an **Outside Micrometer**

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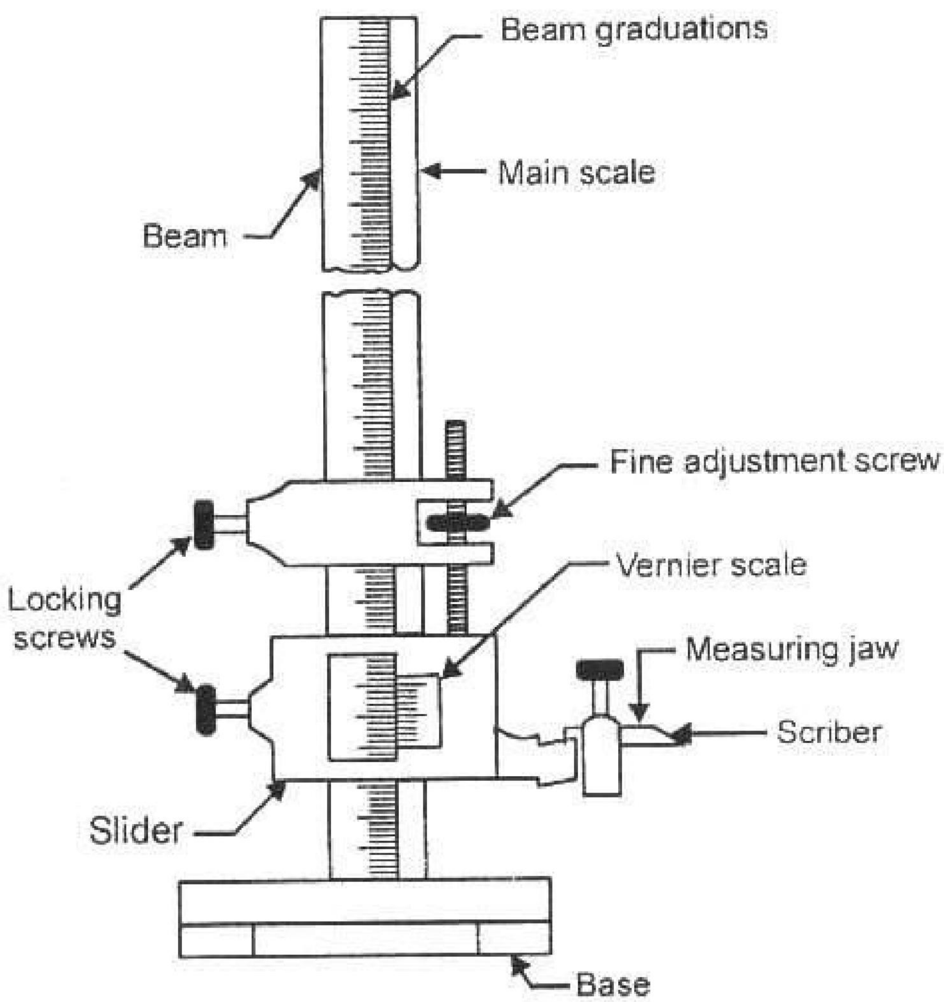
EXPERIMENT NO.: 04

Aim: To determine the height of a given work piece with the help of a **Vernier Height Gauge**.

Apparatus Required: Vernier Height Gauge, Work pieces of different heights.

Theory: The working principle of a vernier height gauge is similar to a vernier caliper. A vernier height gauge is mainly used in the inspection of parts and layout work. It may be used to measure and mark vertical distances above a reference surface.

Construcion : The various important parts of a vernier height gauge are discussed below:



Height gauge.

1. **Base :** The base is made quite robust ensures the rigidity and stability of a height gauge.The underside of the base is relieved leaving a surface round the outside edge of at least 7 mm width. The base is ground and lapped to an accuracy of 0.005mm as measured over the total span of the surface considered.
2. **Beam :** The section of the beam is so chosen as to ensure rigidity during the use. The faces and the guiding edge of the beam is perfectly flat and is square to the base.
3. **Measuring Jaw and Scriber :** The clear projection of measuring jaw from the edge of the beam is made to be at least equal to the projection of the beam from the base. For all positions of the slider, the upper and lower gauging surfaces of the measuring jaw are flat and parallel to the base.
4. **Graduations :** All graduations on the scale and vernier are made to be clearly engraved and thickness of graduations both on scale and vernier is identical. For easy reading, the surfaces of the beam and vernier have dull finish and the graduations lines blackened in.
5. **Slider :** The slider has a good sliding fit along the full working length of beam. A suitable fitting is incorporated to give a fine adjustment of the slider and suitable clamp is provided so that the slider could be effectively clamped to the beam after the final adjustment has been made.

Procedure:

1. Clean the workpieces and instrument.
2. Calculate/Check the least count of the instrument.
3. Place the workpiece properly on the leveled surface plate.
4. Note down the readings on main scale & vernier scale.
5. Take the measurements for at least 3 components by vernier height gauge.
6. Calculate the total reading of vernier height gauge.
7. Complete the observation table.

OBSERVATION TABLE :

Measurements taken using Vernier Height Gauge:

Sr. No.	Reading on Main Scale (MSR)	Reading on Vernier Scale (VSR)	Total Reading = MSR+ (LC*VSR)
1.			
2.			
3.			
4.			
5.			

Result :

Write the name of the work pieces and their measured heights.

Precautions :

1. There should not be any play between sliding jaw & the main scale.
2. Check the instrument for zero error.
3. Parallax or reading error must be avoided.
4. Do not apply undue pressure.

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FOR

Determining the Height of a given Workpiece with the help of a **Vernier Height Gauge**

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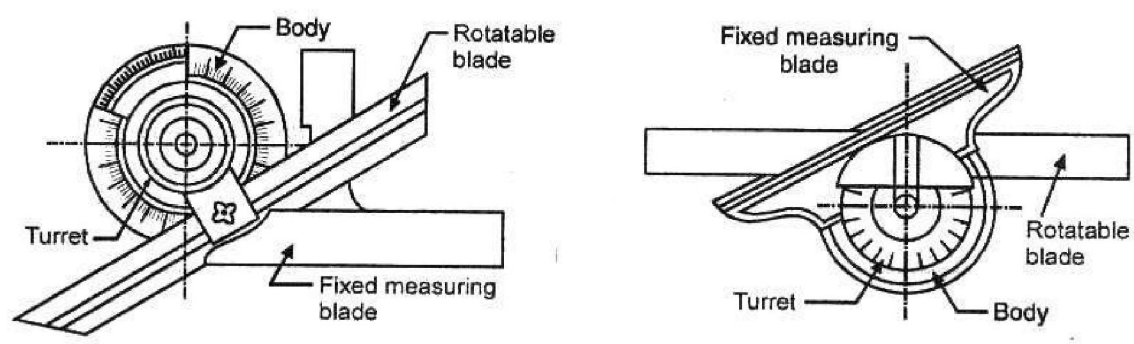
EXPERIMENT NO.: 05

Aim: To find the angle of a given wedge shaped work piece with the help of a **Bevel Protractor**.

Apparatus Required: Bevel Protractor, Wedge shaped workpiece.

Theory: Bevel Protractor is used for measuring the angle between two faces of a component. It consists of a base plate attached to the main body and an adjustable blade to a circular plate containing vernier scale. The adjustable scale is capable of rotating freely about the center of the main scale engraved in the body of the instrument and can be locked in any position. The base plate is made flat so that it would be laid flat upon the workpiece. A bevel protractor can be used to measure angles ranging from 0 to 360 degrees.

Construcion :



Vernier bevel protractor.

The angle between two faces of a component can be simply measured by means of protractor. As shown in figure the protractor has two blades namely **fixed measuring blade** and **rotatable or movable blade** which can be set along the faces conataining the angle. Its body contains a **circular scale** which is extended to form one of the blades. The second blade (rotatable blade) is sliding and can be locked in any position along its length to a **rotating turret** mounted on the **body**. Either the body or the turret carries the divided circular scale, while the other member carries a **vernier** or an index mark.
The figure above shows an ordinary vernier bevel protractor which is a workshop instrument having scale value of 5’.

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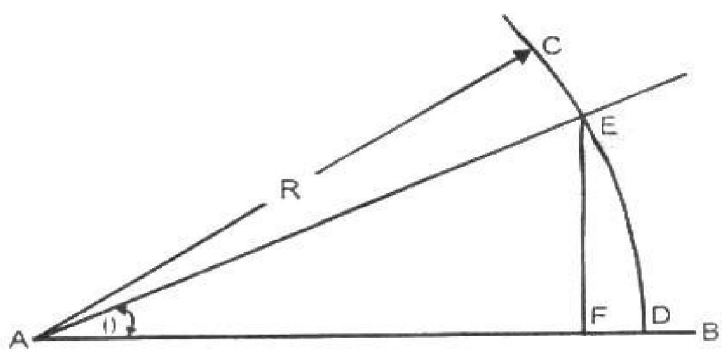
EXPERIMENT NO. 06

AIM : To measure the angle of the given wedge shaped component with the help of a sine bar and slip gauges set.

APPARATUS :

1. Sine bar, height gauge
2. Surface plate, Set of Standard slip gauges, dial indicator with stand
3. The wedge shaped component unknown angle of which is to be measured

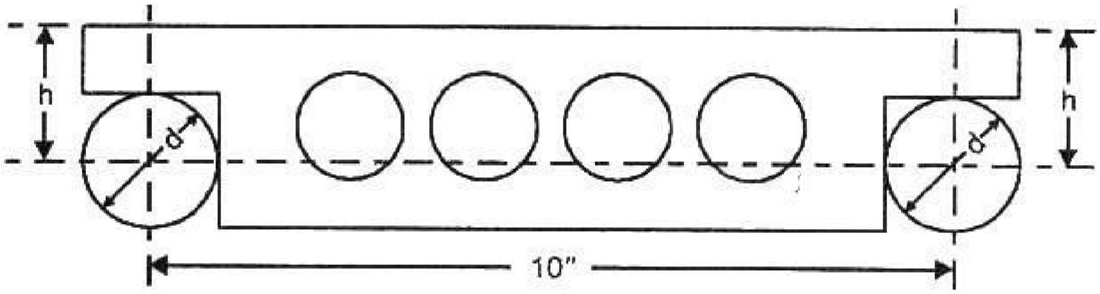
THEORY ; A Sine Bar is a tool used for precise angular measurements through setting out of angles by arranging to convert angular measurements to linear ones. In conjunction with slip gauges, a sine bar can be used for precise measurement of angles and also for locating any work to a given angle within very close limits. The figure below shows the principle of sine bar. If we wish to set out any angle θ, we can do so by setting off a horizontal line AB, next scribing an arc CD with a measured radius R and then setting out a vertical dimension EF= R sin θ. This is quite easily done by means of the sine bar.



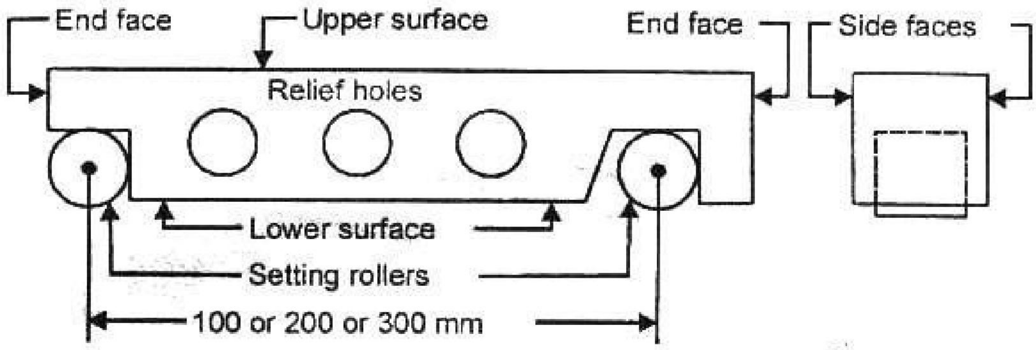
Principle of sine bar.

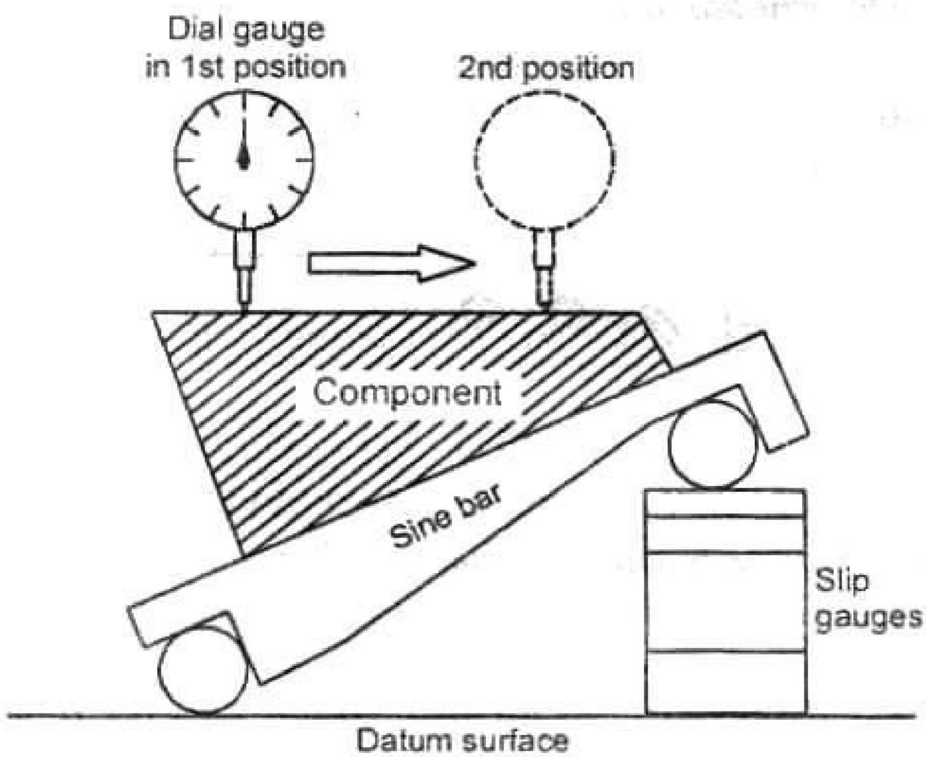
Construction :

A Sine bar is always used in conjunction with datum support (e.g. surface plate) and auxiliary equipments such as slip gauges, dial indicator, angle plate and height gauge. It consists of a steel bar containing **two rollers** of equal diameter attached at the end of it as shown in figure. The axes of these two rollers are mutually parallel to each other and are also parallel to and at equal distance from the **upper surface** of sine bar. The distance between the axes of roller known as length of sine bar is usually 100mm, 200mm & 300mm. Some **relief holes** are drilled in the **body** of the bar to reduce the weight and to facilitate the handling as shown in figure. It is made up of high carbon, high chromium, corrosion resistance steel, hardened ground & stabilized steel.



Commonly used sine bar.





Set up of sine bars for checking small components.

PROCEDURE:

1. Note the length of sine bar L =……….mm
2. Find the approximate angle of the component by using bevel protractor or any other suitable device. Let this angle be θ.
3. Calculate the height of slip gauges (h) required from relation Sin θ = h/L, where L is the length of sine bar. h = L sin θ
4. Select & wring together the required slip gauges for dimension 'h' mm.
5. Place the work piece on sine bar & clamp to the angle plate if necessary as shown.
6. Dial indicator is clamped firmly in dial indicator stand and slight pressure applied so that plunger just touches one end of workpiece.
7. To check the parallelism of upper surface of workpiece, a dial indicator along with the stand is moved from one end of the work and moved to other end.
8. Note the deviation 'δh'. This deviation may be noticed by taking two readings of dial indicator at two ends of work piece top edge.
9. Add / subtract the slip gauges of height 'dh'. Where dh = δh *L/l where 'l' is length of workpiece.
10. Adjust the slip gauges so that deviation of dial indicator is zero from one end to other end.
11. Calculate the height of slip gauges.

Unknown angle = $\sin^{-1}$(Height of slip gauges/Length of sine bar)
= $\sin^{-1}$(h/L) = —————— = ——————

Result:

Write the name of component and its measured angles.

Precautions:

1. Sine bar should not be used for the angles more than 45 degrees.

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FOR

Measuring the Angle of the Given Wedge Shaped Component with the help of a **Sine Bar and Slip Gauges Set**

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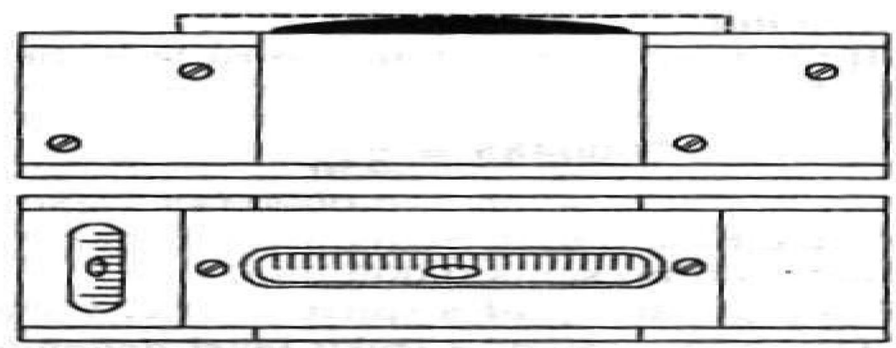
EXPERIMENT NO.: 07

Aim: Leveling of a Surface Plate with the help of a Precision Spirit Level.

Apparatus Required : Surface Plate (Granite or Cast Iron), Precision Spirit Level, Spanner (24-27 mm).

Theory : Spirit Levels are used for measuring small angles or inclinations and also enable to check the level/position of a surface to be determined with respect to the horizontal.

Construction :



Block spirit level.

Surface plate

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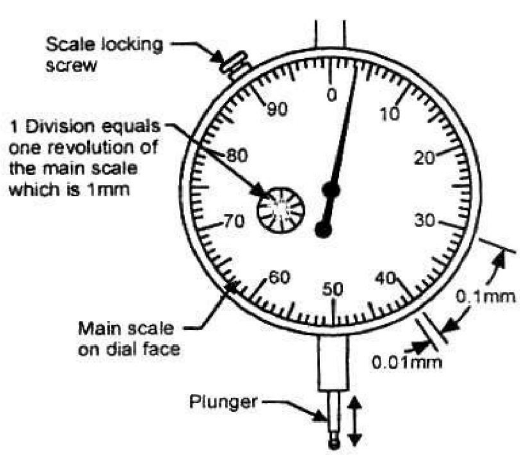
EXPERIMENT NO. 08

AIM: To compare the height of a given cylindrical work piece with the help of a Dial Gauge Indicator.

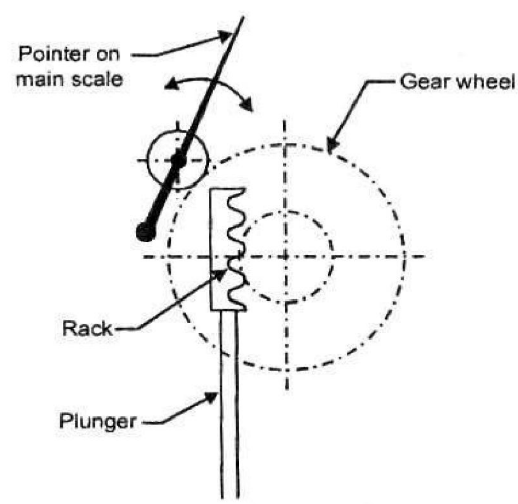
APPARATUS: Vernier Height Gauge, Dial Gauge Indicator, Work piece.

THEORY: A Dial Gauge Indicator is a type of mechanical comparator. The important and essential function of the instrument is to magnify or amplify the small input displacement so that it is displayed on an analogue scale. It detects and displays the small difference between the unknown linear dimension and length of the given standard. The difference in lengths is detected as a displacement of a sensing probe.
The principle of operation of the instrument is shown in the figure below, where it can be seen that the plunger is attached to a rack. Meshing with a gear wheel, the straight or linear motion of the rack is converted into an angular or turning motion, the movement being magnified by using a large gear in mesh with a small gear wheel. It is the small gear wheel that is fitted to the main scale pointer as shown in the figure. This mechanism is simple, reliable and very sensitive.

Construction:



Dial indicator.



Principle of operation of a dial indicator.

EXPERIMENT NO. 09

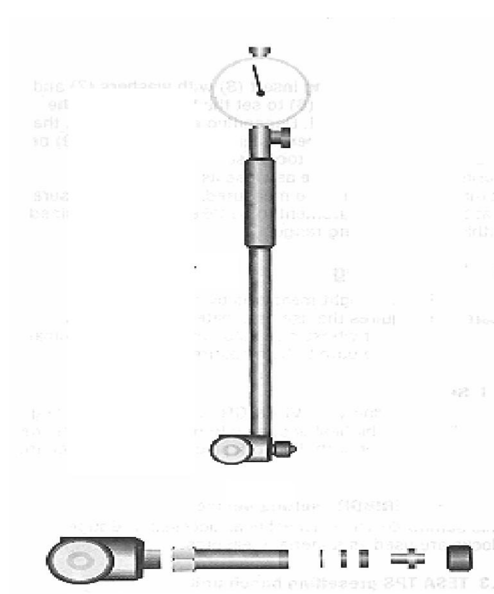
AIM: To check and compare the bores of given cylindrical components with the help of a Dial Bore Gauge

APPARATUS: Dial Bore Gauge, Micrometer or Master Ring Gauge, Work piece.

THEORY:

Dial Bore Gauges allow rapid and accurate checking of bores for size, ovality, taper, wear, etc. All models operate on the proven principle of two diametrically opposed measuring points, one fixed and one moving, plus a spring-loaded centralizing shoe.
To check the actual size of a bore, the gauge must be set to size with a bore of a known diameter, or by means of a micrometer measurement over the fixed and moving points. Inserted into the bore, it is only necessary to "rock" the gauge slowly to locate its measuring axis to the bore, shown by the point of reversal of the indicator hand. The reading at that point is the deviation from set or normal size. A range of interchangeable extension rods allow a single instrument to cover a wide range of bore sizes.

Construction :



Dial-bore gauge when used in conjunction with a **dial gauge indicator**, can give very accurate and precise inside measurements. Available in different ranges of measurable bore sizes, they consist of a **base** that houses an **interchangeable anvil** that sets the range of the measurement and a small **sliding stud** that when compressed will give a reading through a **spring-loaded centralizing shoe** on the gauge or dial portion of the instrument. The dial will have a rotating **bezel** that is rotated to "zero' the gauge at the target measurement, which is set by a separate **micrometer** or master ring gauge. Dial-bore gauges are also useful in checking for taper or out-of-round conditions in a cylinder bore as well as many other inside machinists measurements.

Procedure :

(1.) Determine the rough bore size by using a vernier caliper or any other suitable instrument.

(2.) Select and install the appropriate anvil. The anvil should be long enough to contact the side of the bore and slightly compress the stud when inserted into the hole.

(3.) Select a micrometer in the appropriate range. Set the micrometer for the target measurement.

(4.) Fix the dial indicator into the bore gauge and Insert the anvil and stud between the micrometers machined surfaces.

(5.) Rotate the bezel of the dial indicator until the "zero" is in line with the needle position. The Dial Bore Gauge is now ready to read a measurement relative to the setting.

(6.) Properly Insert the bore gauge into the bore under measurement of the given component. Ensure proper touching of the anvil and the stud with the inner machined surface of the bore.

(7.) Hold the indicator as near to vertical as possible and gently and slightly rock the DB indicator along the anvil/stud axis. The needle will swing clockwise as the tool comes to vertical and the anvil/stud come to their proper position. Read the number on the dial at the point where the needle stops rotating clockwise and attempts to start backing down in a counter-clockwise direction. This is the "relative" measurement. The number may be a positive or a negative . Note this number and remove the DB indicator from the hole.

(8.) Add or subtract the positive or negative number, respectively, from your target or arbitrary number. This final adjusted number is the actual measurement of the hole.

Result:
Write the name of components and their measured measured bore sizes.

Precautions:
1. Do not use an oversized anvil and try to force the indicator, as this will likely destroy the accuracy of the tool.
2. Ensure proper touching of plunger dial tip while setting and taking reference.
3. Ensure proper locking of the dial scale after taking reference.
4. Do not apply undue pressure.
5. Parallax or reading error must be avoided.

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METROLOGY LAB

INSTRUCTION MANNUAL

FOR

Checking and Comparing the Bores of Given Cylindrical Components with the help of a Dial Bore Gauge