1MEA18 – Metrology and Instrumentation
Laboratory Manual

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Experiment No: 1 **Date: ___/___/2013**

Title: To understand construction of Vernier Caliper and calculate its least count.

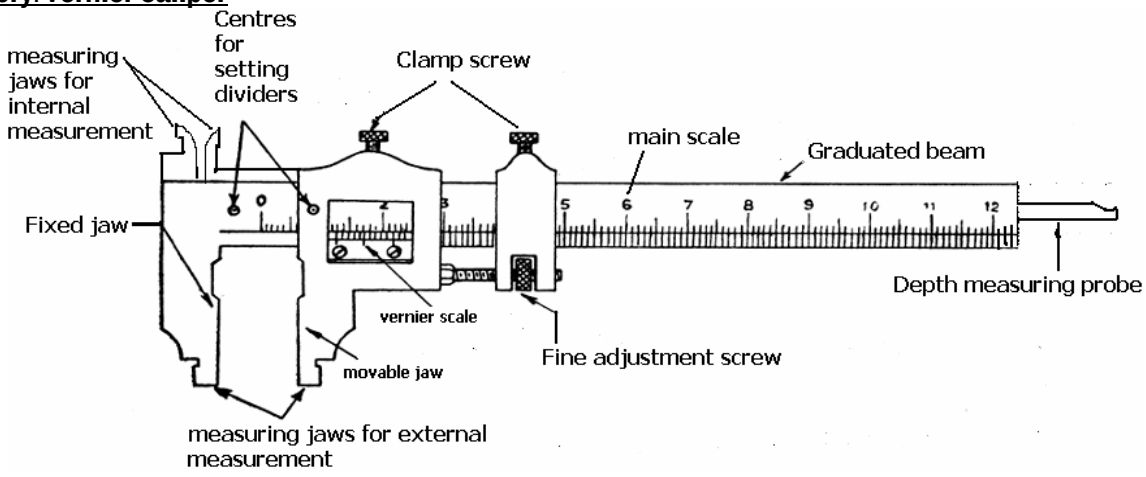
Objectives: After studying this experiment you should be able to:

i. Understand the constructional parts of Vernier Caliper,
ii. how to calculate least count of vernier caliper,
iii. how to take measurement with the help of vernier caliper.

Introduction:

Metrology means science of measurement. Engineering metrology is the measurement of dimensions: length, thickness, diameter, taper angle, flatness, profiles, etc. In engineering, there are various stages during which inspection and measurement is required. Metrology becomes useful while raw material inspection, during production and after the parts are manufactured i.e. final inspections of parts. Measurand is the physical quantity or property like length, angle, diameter, thickness etc to be measured. The various precision linear measuring instruments are vernier caliper, outside micrometer, vernier height gauge, vernier depth gauge, inside micrometer, micrometer depth gauge etc. Such linear measuring instruments measure linear measurements such as length, height, depth, diameter and thickness.

Theory: Vernier Caliper



Following are the constructional parts of vernier caliper:

(1) Fixed scale and movable scale: The Vernier Caliper consists of two scales: one is fixed and the other is movable.
(2) Fixed and movable jaw: The fixed scale is called as main scale which is calibrated on L-shaped frame and carries a fixed jaw. The movable scale, called vernier scale slides over the main scale and carries a movable jaw. The movable jaw as well as the fixed jaw carries measuring tip. When the two jaws are closed the zero of Vernier scale coincides with the zero of main scale. For precise setting of the movable jaw an adjusting screw is provided.
(3) Lock nut: An arrangement is provided to lock the sliding scale on the fixed main scale.
(4) Graduated beam: Main scale markings are there on graduated beam.
(5) Blade or Depth probe: Measures depth.

Least count: The smallest value that can be measured by the instrument is known as its least count.

Least count of Vernier Caliper:

There are two methods to find the least count of Vernier caliper

(a) First Method (Principle of Vernier)

Length of 49 divisions on main scale = Length of 50 divisions on Vernier scale

It means it follows that for the same length if there is n division on main scale then there should be n+1 division on Vernier Scale for the same distance.

- Value of smallest division on main scale = 1 mm and
- Value of smallest division on Vernier scale = 49/50 = 0.98 mm

Least count = Value of smallest division on main scale – value on smallest division on Vernier scale
= 1 – 0.98
= 0.02 mm

(b) Second Method
Least Count = Value of smallest division on Main Scale
Total no. of divisions on Vernier Scale

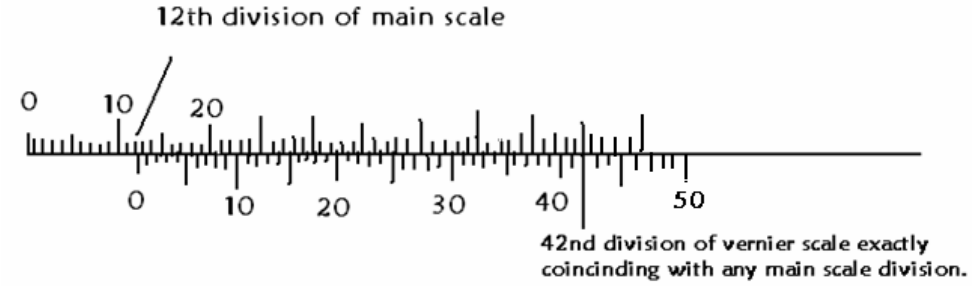
Smallest division on Main scale = 1 mm Total no. of divisions on Vernier Scale = 50 markings
So for this type of Vernier Caliper L.C. = 1/50 = 0.01mm

Observation Table:

Vernier caliper

SrNo.	Range	Smallest division value of main scale	No. of divisions on Vernier	Least count
1				
2				
3				
4				
5				

Reading a vernier caliper:



Formulae for calculating total reading with the help of Vernier caliper is -

Total reading = (Main scale reading) + (Least count of V.C. X Vernier division exactly coincides with main scale division)

Here 12.84mm is the total reading. If 12.84mm is the total reading then the main scale reading is 12. We know that the usual least count of V.C. is 0.02 mm.

Therefore,
12.84 = 12 + (0.02 X Vernier division coinciding with main scale division)
12.84 – 12 = (0.02 X Vernier division coinciding with main scale division)
0.84 = (0.02 X Vernier division coinciding with main scale division)
0.84 = (Vernier division coinciding with main scale division)
0.02
42nd division of Vernier scale exactly coincides with main scale division.
12.84 = 12+ (0.02X42)
= 12.84 mm.

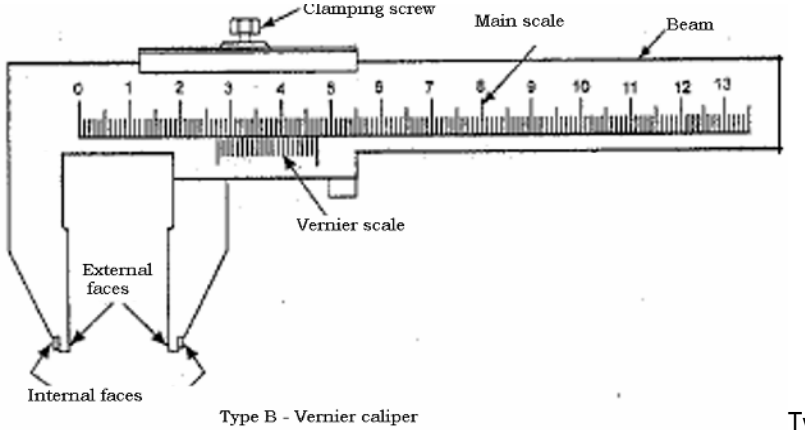
Measurements with vernier caliper: (All readings in mm)
Range: Least count: Make:

Sr. No	Main scale reading A	No of vernier scale division in coincidence	Vernier scale division X Least count B	Total Reading A + B
1				
2				
3				
4				
5				

Precautions in use of Vernier caliper

1. Line of measurement must coincide with line of scale i.e. following Abbe's principle correctly.
2. While measuring outside diameters with Vernier caliper, caliper should not be tilted or twisted.
3. Do not apply unnecessary extra pressure while taking measurements.
4. Handle and grip the instrument near or opposite to the jaws while taking the measurement.
5. Accuracy of measurement primarily depends on two senses – sense of sight (eyes) and sense of touch (feel). Imperfect vision and improper eyesight can cause error so use of proper magnifying glass should be done.

"A" type, "B" type and "C" type of vernier calipers:



Type B - Vernier caliper

Type A has jaws on both sides for external and internal measurements. Type A has a depth probe for depth measurement.. Type B has jaws only for external measurement; they do not have jaws for internal measurement.

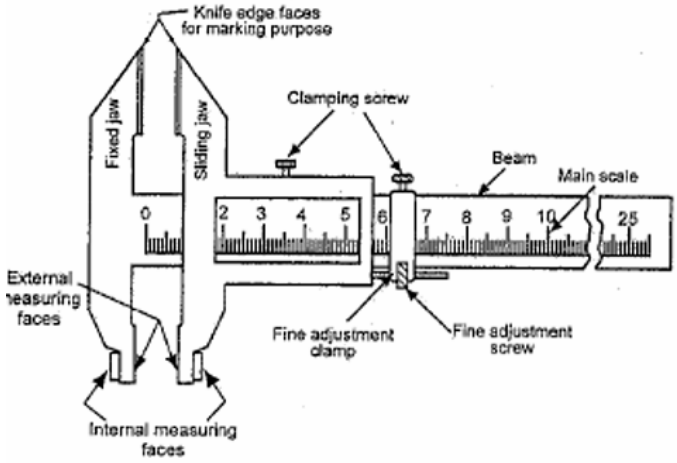


Fig. Type C vernier caliper

Type C has jaws for external measurement only. There are jaws on opposite side but they are not for internal measurement, they are for marking purpose. Hence C type of vernier caliper has jaws for marking purpose. Type B and C do not have depth probe for depth measurement.

Possible errors in Vernier caliper:

Errors in taking reading by use of Vernier caliper are mainly due to manipulation or mishandling of instrument. Various causes of errors are :-

1. Error if the line of measurement does not coincide with the line of scale i.e. *parallax error*.
2. Error due to wear and warping of jaws, where the zeros of two scales will not coincide i.e. *zero error.*
3. Error due to play between sliding jaws on the scale i.e. *backlash error.*
4. If sliding jaw frame becomes worn or warped, it will not slide squarely on main scale and will cause error in measurement.
5. It is difficult to find the Vernier scale division exactly coinciding with main scale division. Error caused by incorrect reading as scales are difficult to read.

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QUIZ

(1) Define (a) Metrology (b) Least count (c) Engineering Metrology (d) Measurand.
(2) What is the scope of metrology in industries?
(3) State different precision linear measuring instruments.
(4) Which linear measurements can be measured by linear measuring instruments?
(5) What is the "Vernier principle"? Explain it with suitable example.
(6) Draw neat sketch of vernier caliper.
(7) List out constructional parts of vernier caliper.
(8) Is it possible to set the dimension 15.73 mm on Vernier Caliper having of least count 0.02mm? Why?
(9) Is it possible to set the dimension of 15.72 mm on vernier caliper having least count of 0.02mm? Why? If yes then show the dimension of 15.72mm on vernier caliper of least count 0.02mm.
(10) Show the following readings on vernier caliper of least count of 0.02mm least count: (a) 6. 84mm (b) 10.28mm.
(11) Differentiate between “A” type, “B” type and “C” type of vernier calipers.
(12) List out two applications of vernier caliper.
(13) State whether the following statements are True or False. Correct the false statements:
   (a) Vernier Caliper has a provision of ratchet for ensuring correct measuring pressure.
   (b) Step height can be measured by vernier caliper.
   (c) “B” type of vernier caliper is used for marking purpose.
   (d) Vernier Caliper obey’s Abbe’s Principle of Alignment.
   (e) Vernier Caliper is an example of Line standard.
(14) Fill in the blanks:
   (a) Line of measurement must coincide with line of scale i.e. following _____ principle correctly.
   (b) _____ error is that error if the line of measurement does not coincide with the line of scale.
   (c) _____ is the science of measurement.
   (d) Error due to wear and warping of jaws, where the zeros of two scales will not coincide i.e. _____ error.
   (e) Error due to play between sliding jaws on the scale i.e. _____ error.

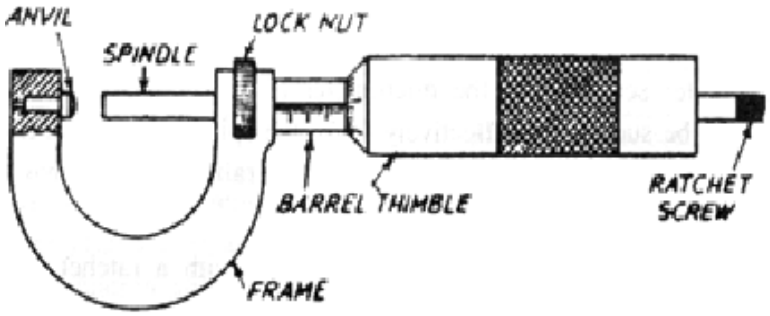
Date and Signature of faculty: _____

Experiment No: 2 **Date: ____/____/2013**

Title: To understand construction of outside micrometer and calculate its least count

Objectives: After studying this experiment you should be able to:

i. Understand the constructional parts of Micrometer,
ii. how to calculate least count of micrometer,
iii. To know how to use Micrometer.



Outside micrometer:

The description of main parts of an outside micrometer is given below:

(1) *U shaped steel frame:* The outside micrometer has "U" shaped or "C" shaped frame. It holds all the micrometer parts together. The gap of the frame permits the maximum diameter or length of the job to be measured.

(2) *Anvil and spindle:* The micrometer has a fixed anvil protruding 3 mm from the left hand side of the frame. Another movable anvil is provided on the front side of the spindle. The anvils are accurately ground and lapped with its measuring faces flat and parallel to the spindle. These are also available with tungsten carbide faces. The spindle is the movable measuring face with the anvil on the front side. The spindle engages with the nut. It should run freely and smoothly throughout the length of its travel.

(3) *Locknut:* A lock nut is provided on the micrometer spindle to lock it when the micrometer is at its correct reading.

(4) *Sleeve or Barrel:* The sleeve is accurately divided and clearly marked in 0.5 mm division along its length, which serves as a main scale. It is chrome plated and adjustable zero setting.

(5) *Thimble:* The thimble can be moved over the barrel. It has 50 equal circular divisions around its circumference. Each division having a value of 0.01mm.

(6) *Ratchet:* The ratchet is provided at the end of the thimble. It is used to assure accurate measurement and to prevent too much pressure being applied to the micrometer. When the spindle reaches near the work surface to be measured the operator uses the ratchet screw to tighten the thimble. The ratchet automatically slips when the correct uniform pressure is applied and prevents the application of too much pressure.

The micrometer usually has a maximum opening of 25mm. They are available in measuring ranges of 0 to 25mm, 25 to 50mm, 125mm to 150mm upto 575 to 600mm.

Principle of Micrometer:

Micrometers work on the principle of screw and nut. We know that when a screw is turned through one revolution, it advances by one pitch distance i.e. one rotation of screw corresponds to a linear movement of a distance equal to pitch of the thread.

Least count of Micrometer:

Micrometer works on the principle of screw and nut. We know that when a screw is turned through nut by one revolution, it advances by one pitch distance i.e. one rotation of screw corresponds to a linear movement of a distance equal to pitch of the thread. If the circumference of the screw is divided into number of equal parts say "n", its rotation through one division will cause the screw to advance through (Pitch/n) length.

$$\text{L.C.} = \frac{\text{Pitch}}{n} \quad \text{minimum length that can be measured}$$

Thus by reducing the pitch of the screw thread or by increasing the number of divisions on the circumference of screw, the length value of one circumferential division (L.C.) can be reduced and accuracy of measurement can be increased considerably.

e.g. micrometer has a screw of 0.50 mm pitch; with a thimble graduated in 50 divisions to provide a direct reading of

$$\text{L.C. of Micrometer} = \frac{\text{Pitch of spindle screw}}{\text{No of divisions on thimble}}$$

Accuracy of the measurement increases as the value of least count decreases. This means that different Vernier Calipers having different value of least count will have different result and different accuracy of the same measurement.

Observation Table:

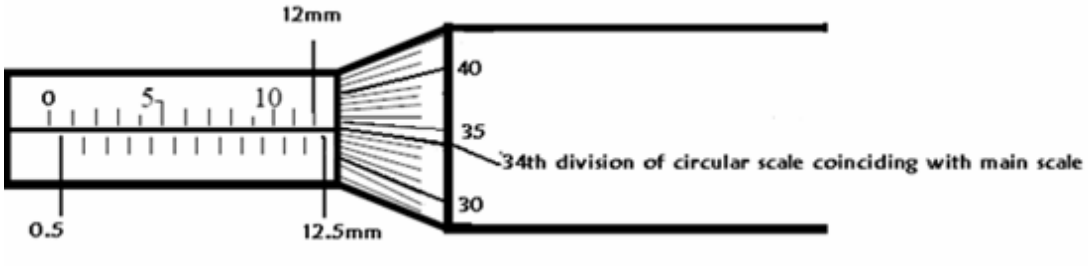
Outside Micrometer

S N	Range	Pitch of spindle screw	No. of divisions on thimble	Least count
1				
2				
3				

Precautions to be taken while using micrometer:

1. Clean the micrometer by wiping of oil dirt, dust etc before using it.
2. Clean the measuring faces of anvil and spindle with a clean piece of paper or cloth.
3. Set the zero reading of instrument before measuring.
4. Hold the workpiece whose dimensions to be measured and micrometer properly. Then turn the thimble with forefinger and thumb, till the measuring tip just touches workpiece. Fine adjustment should be made by ratchet so that uniform pressure is applied.
5. Handle and grip the instrument near the C- frame of micrometer.

Reading the micrometer:



Formulae of calculating total reading with the help of outside micrometer is

Total reading = (Main scale reading) + (Least count of Outside micrometer X Circular scale division exactly coinciding with any main scale division)

Total reading = M.S. reading + (L.C. of O.M. X Circular scale coinciding with M.S.)

Now 12.84 mm is the total reading then main scale reading is 12.5 mm (from the figure shown) and it is known that least count of micrometer is 0.01mm.

12.84 = 12.5 + (0.01 X circular scale division coinciding with main scale)
12.84 – 12.5 = (0.01 X circular scale division coinciding with main scale)
0.34 = circular scale division coinciding with main scale
0.01
34th division of circular scale exactly coincides with the main scale division line.

Total reading = 12.5 + (0.01 X 34)
= 12.84mm.

Measurements with Micrometer:

Range: Least count: Make:

Sr.No	Main scale reading A	No of circular division in coincidence	Circular division X Least count B	Total Reading A + B mm
1				
2				
3				

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Sources of (possible) errors in Micrometer

1. Inaccurate setting of zero reading i.e. *zero error*.
2. Improper working of screw nut arrangement or error due to play between screw - nut i.e. *backlash error.*
3. Applying too much pressure on the thimble or not using the ratchet.
4. Wear on anvil surfaces and spindle surfaces, due to incorrect use.
5. Lack of flatness of anvil surfaces and Lack of parallelism of anvil at some or all parts of the scale.

Vernier Caliper and Outside Micrometer:

Construction of micrometer is stiffer and robust than vernier caliper. Micrometer scale is easier to read while a small magnifying glass may be required to read vernier caliper. Vernier caliper has least count of 0.02mm while outside micrometer has least count of 0.01 mm. Hence outside micrometer is more accurate than vernier caliper. Vernier caliper is available in range of 0 to 150mm, 0 to 300 mm etc while outside micrometer is available in range of 0 to 25mm, 25 to 50mm, 50 to 75 mm etc. Vernier caliper can measure depth as it has depth probe for depth measurement while micrometer cannot measure depth. Micrometer has ratchet for ensure correct measuring pressure while vernier caliper does not have such feature. Vernier caliper can measure inside as well as outside diameter since it has jaws for external and internal measurement while outside micrometer can measure outside diameter only and inside micrometer is required for measuring internal diameter.

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QUIZ

(1) State principle of Micrometer. Draw a neat sketch of outside micrometer. State function of Ratchet in micrometer
(2) Is it possible to set the dimension 15.731 mm on Micrometer having least count 0.01mm? Why?
(3) Show the following readings on outside micrometer of 0.01mm least count: (a) 6.84mm (b) 10.28mm.
(4) Compare Vernier caliper with Micrometer.
(5) State sources of errors and precautions to be taken while using outside micrometer.
(6) State whether the following statements are True or False. Correct the false statements:
    (a) Micrometer obey's Abbe's Principle of Alignment.
    (b) Micrometer has a provision of ratchet for ensuring correct measuring pressure.
(7) Fill in the blanks:
    (a) The micrometer usually has a maximum opening of _____ mm. Hence they are available in measuring ranges of 0 to 25mm, 25 to _____ mm, 125mm to _____mm upto 575 to 600mm.
    (b) The circular scale on micrometer is marked on _____. (barrel, thimble, spindle).
    (c) The use of sleeve or barrel is _____.
    (d) Micrometer works on the principle of _____ and _____.

Date and Signature of faculty: _____

Experiment No: 3 **Date: ____/____/2013**

Title: Vernier Height gauge, Digital Height gauge and Vernier Depth gauge.

Apparatus:
Vernier height gauge (L.C. 0.02 mm and Range 0–300mm), Digital Vernier height gauge, Vernier depth gauge (L.C. 0.02 mm and Range 0–300mm) and Specimen

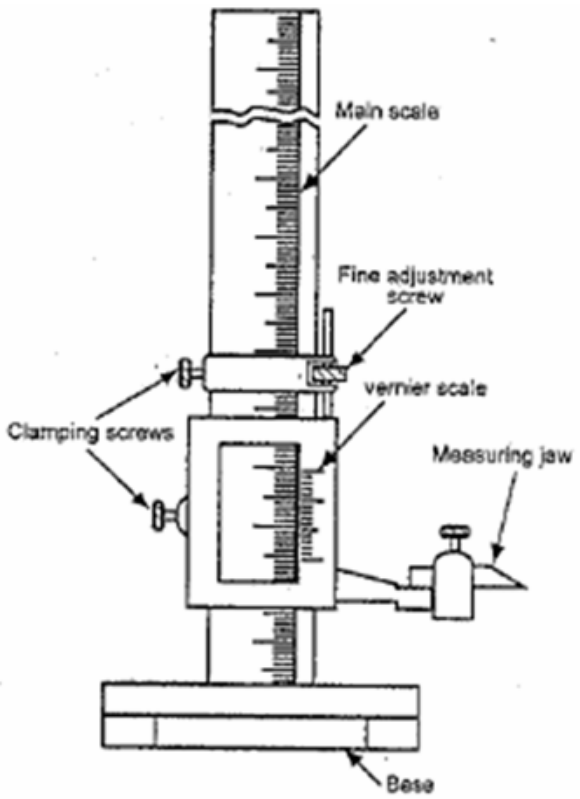

Fig. Vernier height gauge

Vernier Height gauge:
Vernier height gauge is similar to vernier caliper but in this instrument the graduated bar is held in a vertical position and it is used in conjunction with a surface plate. A vernier height gauge consists of (i) a finely ground and lapped base. The base is massive and robust in construction to ensure rigidity and stability. (ii) A vertical graduated beam or column supported on a massive base. (iii) attached to the beam is a sliding vernier head carrying the vernier scale and a clamping screw. (iv) an auxiliary head which is also attached to the beam above the sliding vernier head. It has a fine adjusting and clamping screw. (v) a measuring jaw or scriber attached to the front of the sliding vernier.
The important features of vernier height gauge:

- All the parts are made of good quality steel or stainless steel.
- The beam should be sufficiently rigid square with the base.
- The measuring jaw should have a clear projection from the edge of the beam atleast equal to the projection of the base from the beam.
- The upper and lower gauging surfaces of the measuring jaw shall be flat and parallel to the base.

The scriber should also be of the same nominal depth as the measuring jaw so that it may be reversed.

- The projection of the jaw should be at least 25mm.
- The slider should have a good sliding fit for all along the full working length of the beam.

Observation Table:
For Vernier Height Gauge

Sr. No.	Main scale reading (A) mm	No. of vernier scale division	Vernier scale readings div X L.C. (B)	Total reading A + B

Observation Table:

For Digital Vernier Height Gauge

Sr. No.	Main scale reading (A) mm	No. of Circular scale division on dial	Vernier scale readings div X L.C. (B)	Total reading A + B

Vernier Depth gauge:

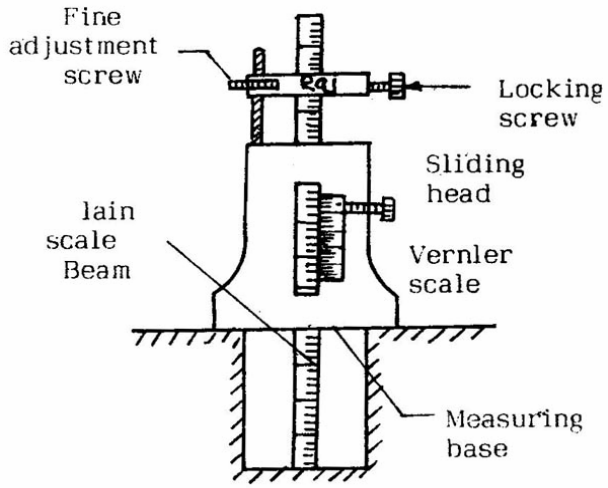

Figure: Vernier Depth Gauge

Vernier depth gauge is used to measure the depth of holes, slots and recesses, to locate centre distances etc. It consists of (i) A sliding head having flat and true base free from curves and waviness.

(ii) A graduated beam known as main scale. The sliding head slides over the graduated beam.

(iii) An auxiliary head with a fine adjustment and a clamping screw. The beam is perpendicular to the base in both directions and its end square and flat. The end of the sliding head can be set at any point with fine adjustment screw depending upon the sense of correct feel. The clamping screw is then tightened and the instrument is removed from the hole and readings are taken in the same way as taken by vernier caliper. While using the instrument it should be ensured that the reference surface on which the depth gauge base is rested, is satisfactorily true, flat and square.

For Vernier Depth Gauge

Sr. No.	Main scale reading (A) mm	No. of vernier scale division	Vernier scale readings div X L.C. (B)	Total reading A + B

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QUIZ

(1) What is the difference between vernier caliper and vernier height gauge?
(2) What is the least count of vernier height gauge and vernier depth gauge?
(3) What is the range of vernier height gauge and vernier depth gauge?
(4) State essential features of Vernier Height gauge.
(5) Draw a neat sketch of vernier height gauge.
(6) Draw a neat sketch of vernier depth gauge.
(7) Write two limitations of vernier instruments.
(8) Fill in the blanks:
   (a) The main scale of vernier height gauge is engraved on _____.
   (b) The_____ scale of vernier height gauge is engraved on sliding vernier head.

(c) An _____ head is also attached to vertical graduated beam above sliding vernier head.
(d) Auxiliary head has parts like _____.
(e) Scriber is used for _____ purpose.

(9) State whether the following statements are True or False. Correct the False statements:
(a) Vernier height gauge follows the principle of Abbe's principle of alignment.
(b) Vernier depth gauge does not follow the principle of Abbe's principle of alignment.
(c) Sliding vernier head is attached to vertical graduated beam.
(d) Vernier depth gauge has a fixed base.

Date and Signature of faculty: _____

Experiment No: 4 **Date: ____/____/2013**

Title: Depth micrometer and Vernier Micrometer.

Objectives: After studying this experiment you should be able to:

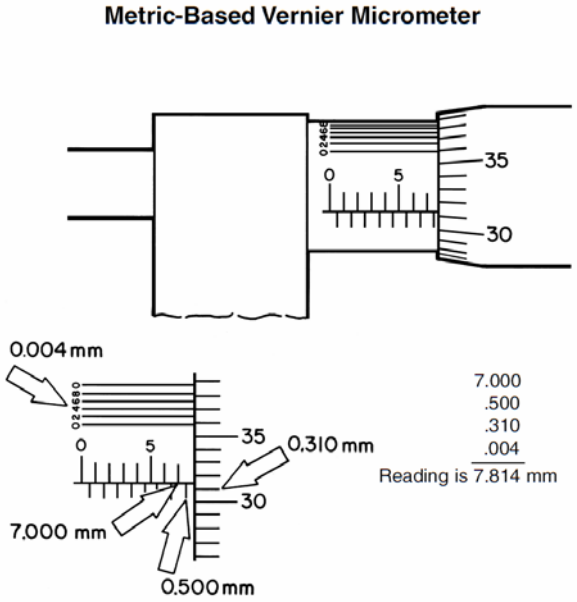
i. how to assemble and use depth micrometer,
ii. how to calculate least count of vernier micrometer.

Apparatus:

(1) Vernier Micrometer (L.C. 0.001mm, Range 0 to 25mm)
(2) Micrometer Depth Gauge (L.C. 0.01mm, Range 0 to 150mm)
(3) Specimen

Theory:

Vernier Micrometer:



When a vernier principle is applied to an outside micrometer, it works as vernier micrometer; hence accuracy of outside micrometer is increased. It gives reading with an accuracy of 0.001 mm. The vernier scale is engraved on the micrometer barrel. There are 10 divisions on the vernier scale, and these are equal to 9 divisions on the thimble. Hence one division on the vernier.

Scale is equal to 1/10 X 9 = 9/10 that of the thimble. But one division on thimble is equal to 0.01mm (similar to conventional micrometer). Therefore one division on vernier scale = 9/10 X 0.01 = 0.009mm.
The least count according to vernier principle by vernier will be, value of smallest division on thimble – value of smallest division on vernier scale = 0.01 – 0.009mm = 0.001mm.

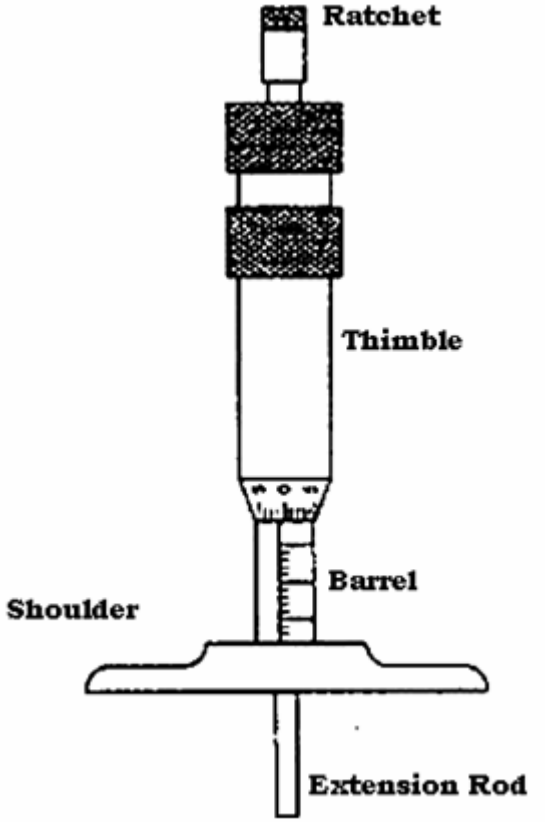
Observation Table: Vernier Micrometer:

Make: Least count:

Sr. No.	Main scale reading A	No. of circular scale division B	No. of vernier scale division C	Total reading A + B + C

Depth micrometer:

It is also called as micrometer depth gauge. Depth micrometer as the name indicates is used for measuring the depth of holes, slots and recesses. It has a shoulder, which acts as a reference surface. The shoulder is held firmly and perpendicular to the centre line of the hole. Extension rods are in steps of 25mm, used for longer range of measurement. The extension rods can easily be inserted by removing the spindle cap. When the cap is replaced, the rod is held firmly against the reference surface. The extension rods are marked with their respective capacity and are square with the base in any position. The measuring faces of the base and rods are hardened.



Observation Table: Depth Micrometer:

Make: Least count:

SN	Main scale reading A	No. of circular scale division B	Circular scale readings division X Least count C	Extension rod selected	Total reading A + B + C

QUIZ

(1) Draw neat sketch of depth micrometer.

(2) Name and explain constructional parts of depth micrometer.

(3) Explain how to calculate the least count of vernier micrometer.

Date and Signature of faculty: _____

Experiment No: 5 **Date:** ___/___/2013

Title: Direct and indirect measuring instruments like Screw pitch gauge, radius gauge, small hole gauge, Telescopic gauge and Feeler gauge.

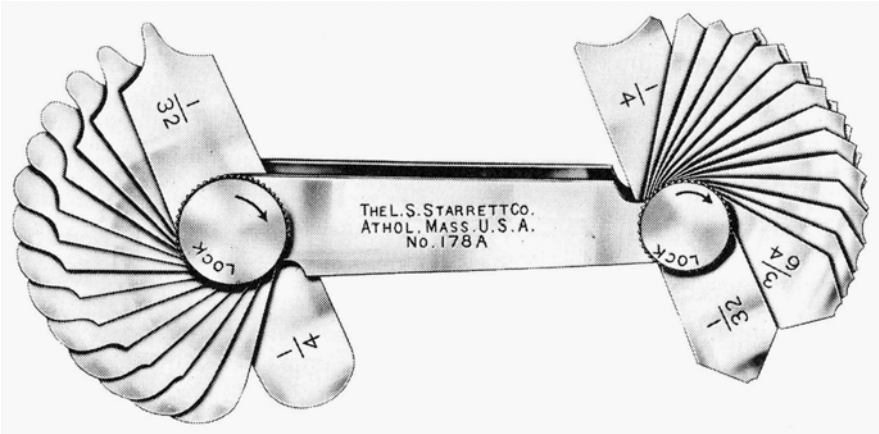
Objectives:

Students will be able to know

i. know how to use a radius gauge, screw gauge and feeler gauge,
ii. know how to use a small hole gauge and telescopic gauge,
iii. understand difference between direct and indirect instruments.

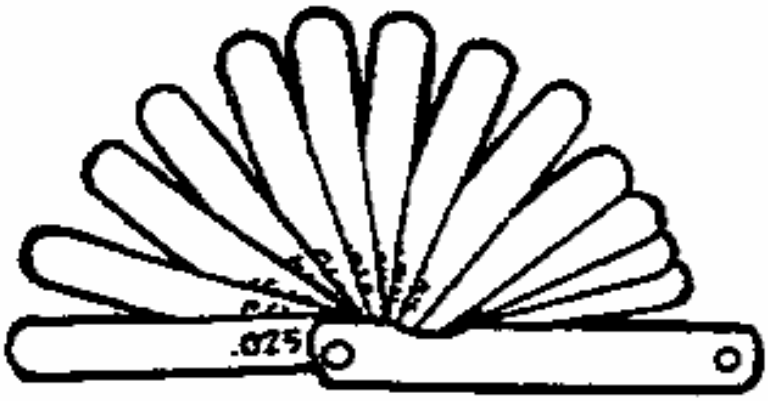
Theory:

(A) Radius Gauges:



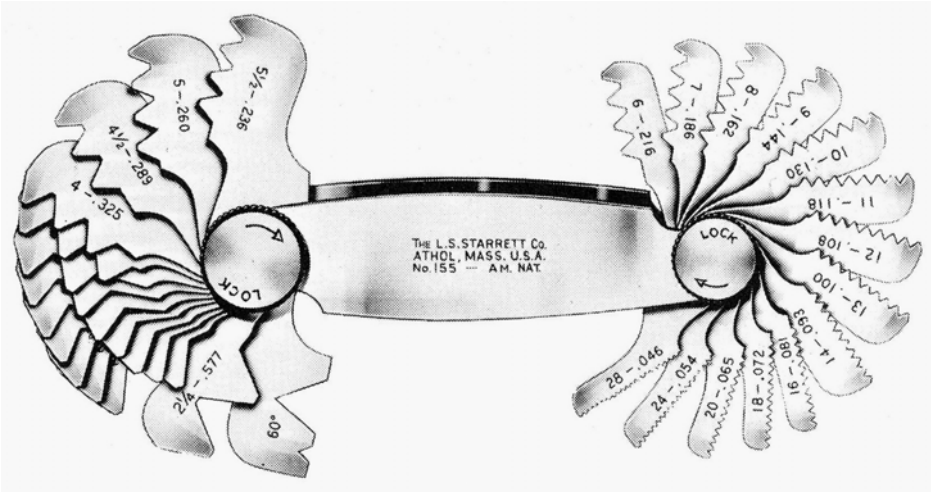
Radius gauges are employed for checking external and internal radii on a curved surface. Radius gauges consists of set of blades. Corresponding radius is permanently marked on each blade. The set of blades with internal radius on one side and external radius on the other so that it may be suitable for checking fillets as well as radius. The passage of light between the gauge and the work allows the radius to be checked properly.

(B) Feeler Gauge:



Feeler gauge is used to measure the clearance between the two mating parts. For example, it can be used in gauging of the clearance between the piston and cylinder and also for adjusting the spark plug between the distributor points of an automobile. The feeler gauge set consists of narrow strips of sheet steel of different thickness assembled together in holder. A set of feeler gauge consists of series of blades of thickness varying from 0.03mm to 1mm. The width of blade is 12 mm at heal and tapered for outer part of their length so that the width of tip is 6mm.

(C) Screw Pitch Gauge:



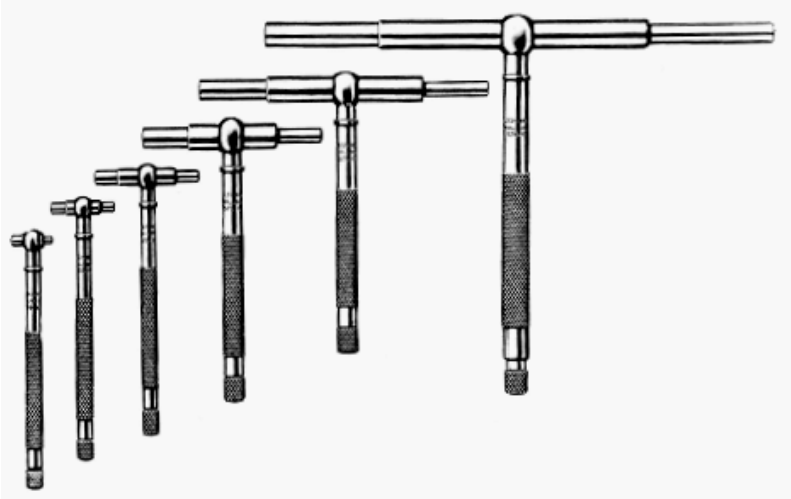
Screw pitch gauge is used to check the pitch of screw thread. They quickly determine the pitch of thread by matching the teeth on the strips with the teeth on the work.

(D) Small Hole Gauge:

Fig: Small hole gauge:

Small hole gauges are used to measure the diameter of holes of smaller size and they are used specially when holes are drilled in the inside area of workpiece and measurement is not possible by the used of direct instruments like vernier caliper and micrometers.

Figure: Telescopic Gauge:



(E) Telescopic Gauge:

Telescopic gauges are indirect and non- graduated instruments used for linear measurement. They are used in the situations where other instruments like Vernier caliper and micrometer cannot approach the contours of workpiece whose dimension is to be measured. For example for T slot measurement, intermediate bore diameter.

Observation Table:

Sr. No	Name of instrument	Observation

QUIZ

(1) State applications of different indirect instruments like (a) Feeler gauge (b) Radius gauge (c) Telescopic gauge (d) Screw pitch gauge
(2) Compare direct instruments and indirect measuring instruments.
(3) What is the difference between Radius gauge, Feeler gauge and Screw pitch gauge?
(4) Draw neat sketches of Feeler gauge and Radius gauge.
(5) When are small hole gauges? Draw neat sketch of small hole gauge.
(6) Draw neat sketches of Telescopic gauge and Screw pitch gauge.

Date and Signature of faculty: _____

Experiment No: 6 **Date:**

Title: Vernier Bevel Protractor

Objectives:

Students will be able to know

i. Understand different parts of vernier bevel protractor,
ii. Know the use and working of bevel protractor,
iii. Understand the use of vernier bevel protractor.

Bevel Protractor:

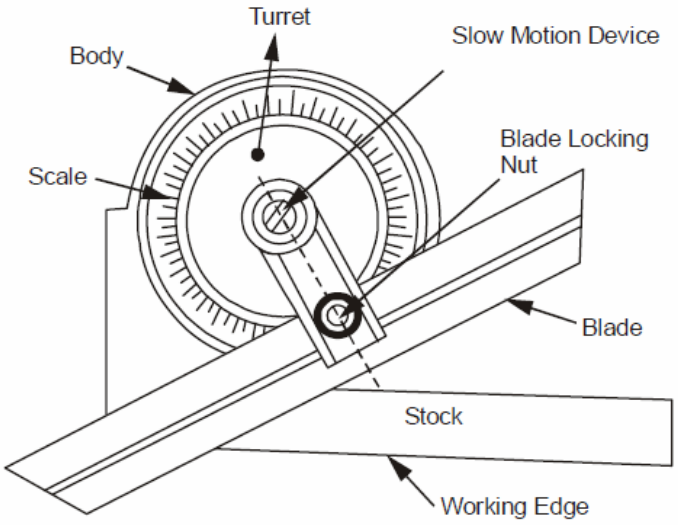


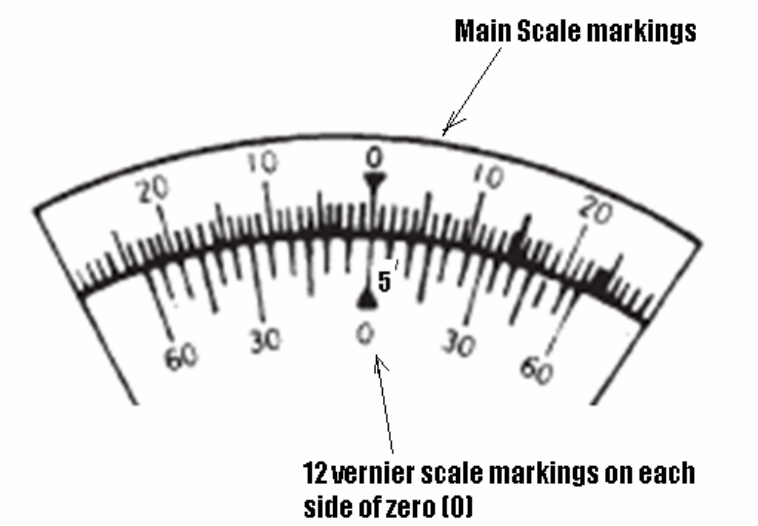
Figure : Bevel Protractor

It is also called universal bevel protractor. It is one of the simplest instruments for angular measurement. It is a direct type of angular measuring instrument. The range of this instrument is 0 to 360 degrees i.e. it can measure angles upto 360^0 which any other angular metrological instrument cannot measure. It has two arms (Fixed blade and Adjustable Blade), which can be set along the faces and a circular scale to indicate the angle between them. Workpiece is set in between these two arms (two blades, fixed blade and adjustable blade), and the difference of two scale (main scale and vernier scale) readings gives accurate measurement.

Main parts of bevel protractor are

1. Fixed Base blade and a circular body is attached to it.
2. Adjustable blade.
3. Blade clamp.
4. Scale magnifier lens.
5. Acute angle attachment.

Note the reading, magnifying lens has been provided for easy reading of the instrument. Main scale is circular and is graduated in degrees on the circular body. Main scale graduations are all around the circular body which is attached to fixed base blade. Fixed base blade also called as stock is attached to circular body of bevel protractor as shown in figure. Once the reading is fixed, blade clamp fixes the reading. Blades are about 150 mm long or 300mm long, 13mm wide and 2mm thick. Its ends are beveled at angles of 45 degree and 60 degree. Vernier scale is also marked on turret which can rotate all over the fixed body. Adjustable blade can pass through the slot provided in turret. So as the turret rotates, adjustable blade also rotates full 360 degrees. There are 12 graduations of Vernier scale starting from 0 to 60^o on both sides of zero of Vernier scale as shown in fig below.



Least count of Vernier bevel protractor= smallest division on main scale
Total no of divisions on Vernier scale

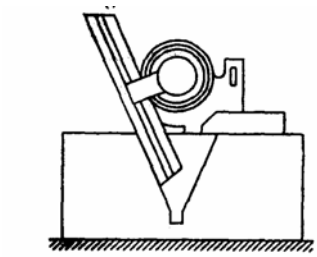
=1° (equal to 60') i.e. 60
12

= 5 minutes (written as 5')

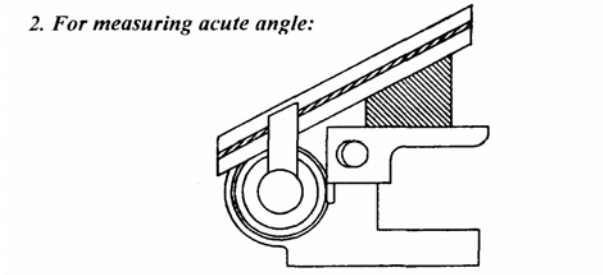
Applications of Vernier Bevel Protractor:

The bevel protractor can be used in the following applications:

1. For checking a 'V' block:



2. *For measuring acute angle:*



Procedure to conduct experiment:

(a) Study the bevel protractor and identify its main parts.
(b) Introduce the adjustable blade in the slot of body and clamp it with the help of knob in the convenient position.
(c) Place the working edge of the stock on one surface of the job and rotate the turret holding the blade so that the working edge of the blade coincides with another surface of the job. Fix the turret and read the angle.
(d) Measure the angles of the sample pieces with the bevel protractor and record the reading in the proforma suggested.

Observation Table:

Sr. No.	Notation of Angle	Vernier Bevel Protractor	Remarks
1	A		
2	B		
3	C		

QUIZ

(1) Is it a direct or indirect angular measuring instrument?
(2) Draw a neat sketch of vernier bevel protractor and explain its construction.
(3) How to calculate least count of vernier bevel protractor? Explain.
(4) How to calculate least count of vernier bevel protractor?
(5) State the range of vernier Bevel Protractor.
(6) State applications of vernier bevel protractor.

Date and Signature of faculty: _____

Experiment No: 7 **Date:** ___/___/2013

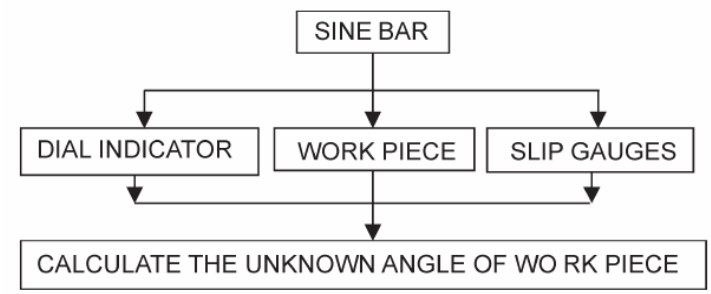
Title: To find unknown angle of a given component using Sine Bar.

Objectives:

Students will be able to know

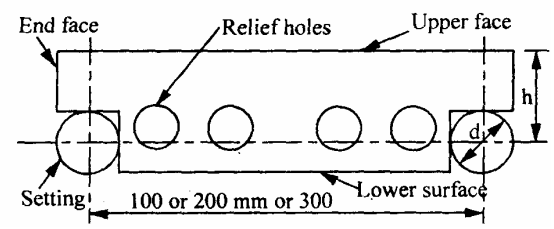
i. Understand different parts of sine,
ii. Know the principle, use and working of sine bar,

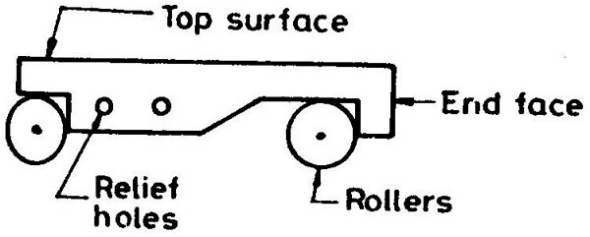
Concept Structure:



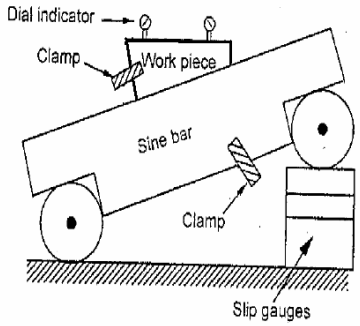
Sine Bar:

Sine bar is a precision instrument used along with slip gauges for accurate angle measurements or angle setting. Sine bar consists of an accurate straight bar in which two accurately lapped cylindrical plugs or rollers are located with extreme position.





The straight bar are made of high carbon, high chromium, corrosion resistant steel and the surfaces are hardened, grounded and lapped. Ends of the straight bar are stepped so that the plugs can be screwed at each step. Plugs are the two rollers of same diameter fixed at a distance L between them and is called as length of the bar. This distance L is the centre to centre distance of plugs is which is generally 100, 200, 300 mm and so on.



Use of Sine bar:

The workpiece whose angle is to be measured is placed on sine bar. Below one roller of sine bar, slip gauges are placed. Slip gauges are added till the workpiece surface is straight. Dial indicator is moved from one end of workpiece till another end. Slip gauges are added till dial pointer does not move from zero position.

#
#
#
#
#

Principle:-

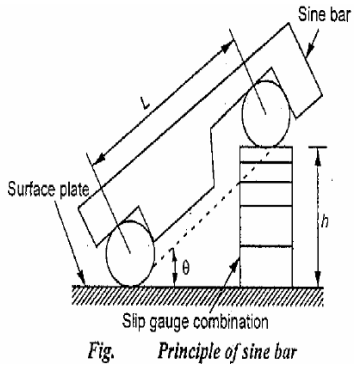
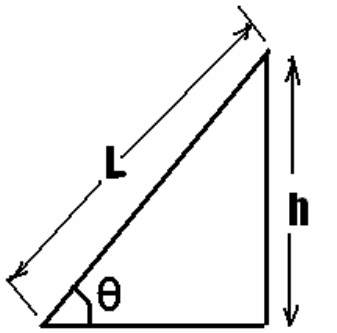


Fig. Principle of sine bar



The use of sine bar is based on the laws of trigonometry. When sine bar set up is made for the purpose of angle measurement as shown below, sine bar itself forms hypotenuse of right angle triangle and slip gauges form the side opposite to the required angle. Sin θ= (h/L)

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

Angle θ is determined by an indirect method as a function of sine so this device is called as sine bar. Sine bar is always used in conjunction with slip gauge and dial indicator for the measurement of angle.

Stepwise 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 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 'h'. 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 = h *L/l '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) = _____.

Observation and Calculations:

L = Distance between axes of supporting roller of sine bar = _____mm

h = height of slip gauge = _____ mm

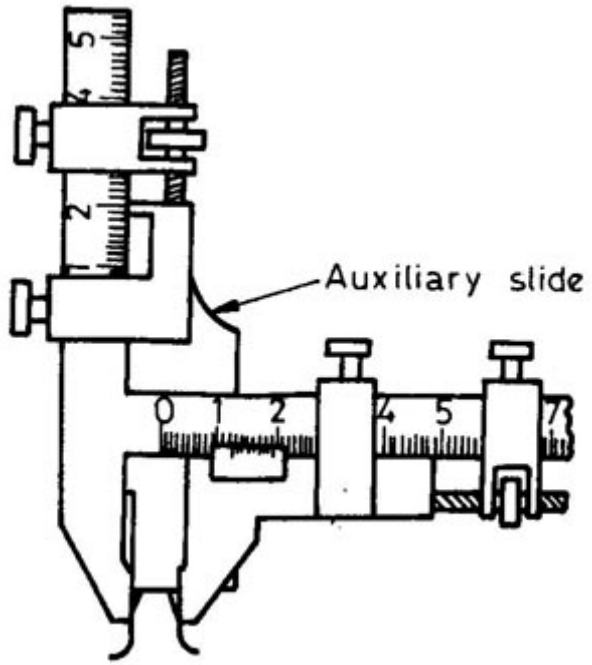
QUIZ

(1) With the help of neat sketch, explain how to use sine bar for angular measurement?
(2) State two applications of sine bar.
(3) State two limitations of sine bar.
(4) Sine bar is used for accurate measurement of angles. True or False. Give reasons if the answer is false.
(5) Sine bars are specified by diameters of rollers. True or False. Give reason if statement is false.
(6) Why relief holes are provided on sine bar?
(7) State the specifications of sine bar.

Date and Signature of faculty: _____

Experiment No: 8 **Date:** ___/___/2013

Title: Gear Teeth Measurement



Objectives:

Students will be able to

1. Understand working and use of Gear tooth Vernier caliper,
2. Understand the importance of gear measurement,

Apparatus:

(a) Spur Gear (b) Gear tooth Vernier Caliper

Theory:

The main parameters determining the profile of a spur gears are pressure angle, circular pitch, tooth thickness, crest circle diameter and root circle diameter. Here we describe the method for measuring of tooth thickness by means of a gear tooth vernier caliper. The measuring principle is based upon the determination of the exact depth from the crest of the tooth at which the chordal thickness should be measured. The correct depth must ensure that the chordal tooth thickness is measured at the pitch circle. For spur gears, it can be shown that:

$$hm = m + \frac{dp}{2}\left(1 - \cos\frac{(90)}{z}\right) \quad \text{..... eqn (1)}$$

Where m = module, dp = pitch circle diameter, z = no. of teeth

Procedure

(1) Count number of teeth (z) on the gear. (2) Measure outside diameter (do) of the gear.
(3) Calculate module m = do/(z+2) (4) Calculate pitch circle diameter dp = mz.
(5) Calculate value of h from equation (1).
(6) Set the gear tooth vernier caliper from depth and measure width w of gear teeth
(7) Repeat the measurements on other teeth and determine the average value.

Observation Table:

Number of teeth on gear, z = _____ and outside gear dia do = _____

Sr. No	Width (w)	Height (h)	Sr. No	Width (w)	Height (h)
1			9		
2			10		
3			11		
4			12		
5			13		
6			14		
7			15		
8					

Calculation:

$$hm = m + \frac{dp}{2}\left(1 - \cos\left(\frac{90}{z}\right)\right)$$

$$w = dp \sin\left(\frac{90}{z}\right)$$

QUIZ

(1) What is the use of gear tooth vernier caliper?

(2) Explain why chordal width of spur gear is an important dimension to measure.

Date and Signature of faculty: _____

Experiment No: 9 **Date:** ___/___/2013

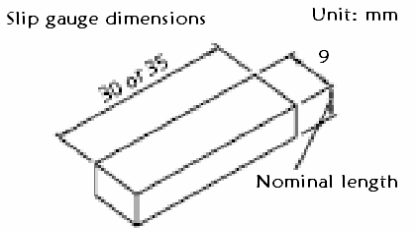
Title: Micrometer calibration by Slip Gauges

Objectives:

Students will be able to know

i. to know the use and working of slip gauges,
ii. to know the classification and working of slip gauges,

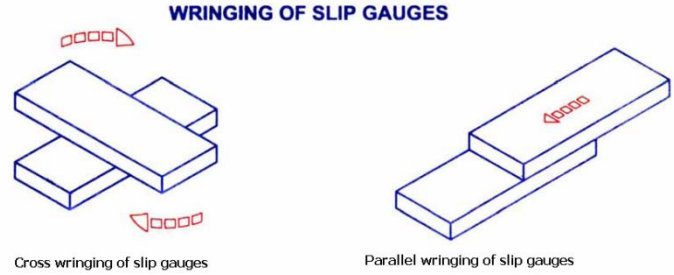
Theory:



RECTANGULAR GAUGE BLOCK

Slip gauges are end standards used in linear measurements. They are used in workshop for work where a tolerance as low as 0.001mm is needed. Slip gauges were invented by Swedish engineer, C.E. Johnson, so they are also called Johnson gauges. Slip gauges are rectangular blocks, made of high grade steel, having cross section about 30mm X10mm. These blocks are made into required sizes and hardened to resist wear and allowed to stabilize so as to relieve internal stresses. This prevents occurrence of size and shape variations. After hardening the blocks, measuring faces are carefully finished to fine degree of surface finish, flatness and accuracy. This high grade surface finish is obtained by super finishing process known as lapping.

Wringing of slip gauges:



The measuring face of the gauges is flat and it possesses high surface finish. If two slip gauges are forced against each other on measuring faces, because of contact pressure, gauges stick together and considerable force is required to separate these blocks. This is known as wringing of slip gauges. Thus, wringing refers to condition of intimate and complete contact and of permanent adhesion between measuring faces. Slip gauges are wrung to build desired dimension. Slip gauges are wrung together by hand and no other external means.

Figure shows 1) Parallel wringing of slip gauges and 2) Cross wringing of slip gauges.

In cross wringing – the two slip gauges are first cleaned to remove dirt, then they are placed together at right angles in the form of cross and then rotated through 90^{o}, while being pressed together. This method causes less rubbing of surfaces. Almost any dimension may be built by suitable combination of gauges. Wringing phenomenon is purely due to surface contact and molecular adhesion of metal of blocks. Hence,

"wringing is defined as the property of measuring faces of gauge blocks of adhering, by sliding or pressing the gauge against measuring faces of other gauge blocks or reference faces or datum surfaces without the use of external means."

Uses of slip gauges.

1. As a reference standard.
2. For verification and calibration of measuring apparatus.
3. For adjustment of indicating devices.
4. For direct measurement.
5. For setting of various types of comparators.

Particulars of M87 and M45 slip gauge set.

M87 is a special set of slip gauges.

Range (mm)	Steps	Pieces
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 90	10	0
1.005	-	1

M45 is a normal set of slip gauges.

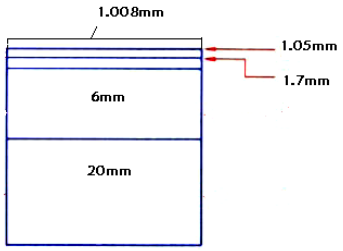
Range (mm)	Steps	Pieces
1.001 to 1.009	0.001	9
1.01 to 1.09	0.01	9
1.1 to 1.9	0.1	9
1 to 9	1	9
10 to 90	10	9
		Total 45

Determining the dimension of 29.758mm by M45 slip gauge set:

Rule 1:-Minimum number of slip gauges should be used to build dimension.

Rule 2:- Always start with the last decimal place.

Procedure	Last decimal	Calculation
a) Write the required dimension		29.758
b) Starting with last decimal place i.e. 0.008 But we can use 1.008 as to follow rule 1.	0.008	- 1.008
c) After subtraction the value remaining is 28.75. Here the last decimal place is 0.05 but we can use 1.05 slip gauge set so as to follow rule 1	0.05	28.75 - 1.05
d) Value remaining is 27.7 i.e last decimal place is 0.7 But we can use 1.7mm slip gauge so as to follow rule 1.	0.7	27.7 - 1.7
e) Now the value remaining is 26 mm and we have 6mm gauge block available.	6.0	26.0 - 6.0
f) Final value is 20mm and this gauge is available. Remainder should always be zero	20mm	20.0 - 20.0 = 0.0



Hence to build the dimension of 29.758 we need slip gauges of 20mm, 6mm, 1.7mm, 1.05mm and 1.008mm.

Procedure of performing experiment:

(1) Clean the fixed vice and micrometer
(2) Clamp the micrometer in vice putting cushioning material between micrometer and jaws of vice to protect the micrometer from probable damage due to clamping force.
(3) Make pile of guage blocks and insert between two anvils of the micrometer and take reading.

(4) Increase the value of gauge blocks pile and take next few readings.
(5) Then decrease the value of gauge blocks pile and take same readings in decreasing order.
(6) Tabulate the readings
(7) After cleaning the place the gauge blocks should be placed in their respective places.

Observation table:

Range: Least count: Make:

Sr. No	Slip gauges in combination	Micrometer reading in mm				
		Increasing	Decreasing	Average	Error	Correction
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Graphs:

Following graphs are to be drawn:

(1) Slip gauges combination – Micrometer average
(2) Slip gauges combination – Error
(3) Micrometer average reading – correction

Conclusion:

Signature of Faculty: _____

Experiment No: 10 **Date:** ___/___/2013

Title: Study of Tool Maker's Microsocope.

Objectives:

After performing this experiment, you should be able to

- appreciate the importance of precision measurement,
- know how precise measurements can be taken with this instrument,
- explain the field of application/working of this instrument, and
- understand the principle of working of tool room microscope.

Introduction:

Engineering microscopes designed to satisfy various measuring needs of toolmaker's are known as toolmaker's microscopes. A plain toolmaker's microscope is primarily intended for a particular application. On the other hand, universal toolmaker's microscope is adaptable to an uncommonly wide range of measuring tasks. A toolmaker's microscope is designed for measurements of parts of complex forms, e.g. profile of external threads, tools, templates and gauges. It can also be used for measuring centre-to-centre distance of holes in any planes, as well as the co-ordinate of the outline of a complex template gauges.

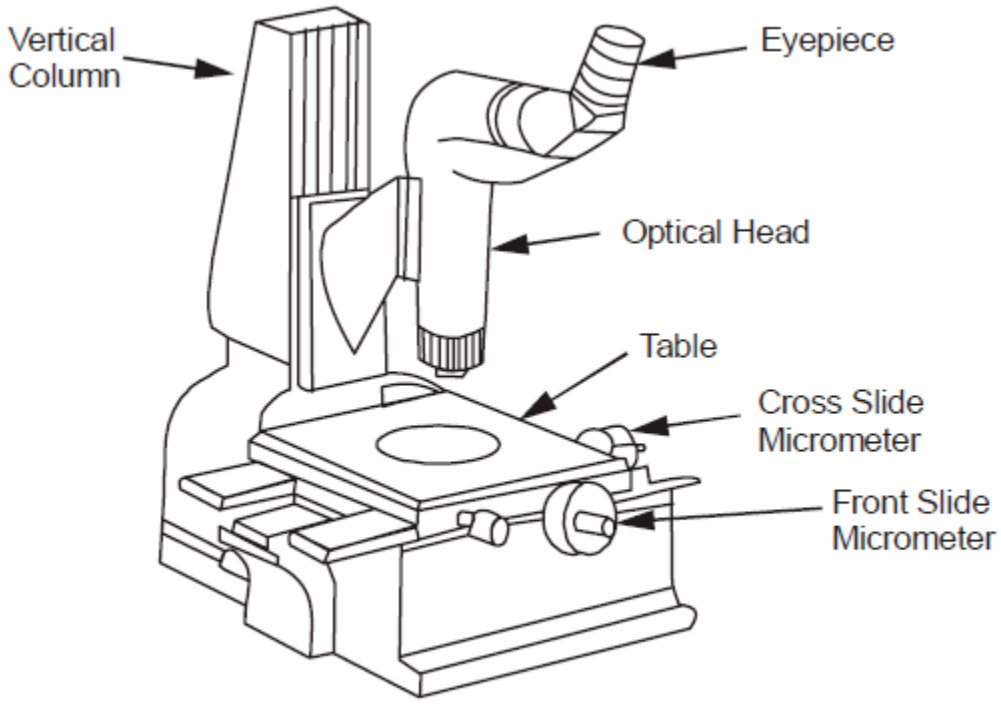


Figure : Tool Room Microscope

BRIEF DESCRIPTION OF INSTRUMENT

It consists of optical head, which can be adjusted vertically along the ways of the vertical column and can be clamped in any position. The working table is secured on a heavy hollow base. The table has a compound slide to give longitudinal and lateral movements actuated by accurate micrometer screws having thimble scales and vernier. At the back of the base is a light source, which provides a horizontal beam of light reflected upwards by 90^{o} towards the table. This beam of light passes through a transparent glass plate on which flat parts to be checked are placed. A shadow image of the outline of the contour passes the objective of the optical head and is projected by a combination of three prisms to a ground glass screen. Observations are made through the eyepiece of the optical head.

Figure gives the views of a tool room microscope.

Cross lines are engraved on the glass screen, which can be rotated through 360^{o}, and these lines make the measurements. The angle of rotation of screen can be read on the optical head. The eyepiece field of view contains an illuminated circular scale with a division value of one minute. Adjusting optical head tube performs focussing.