University Of Jordan
Faculty of Engineering and Technology
Mechanical Engineering Department

Measurement Lab.

EXPERIMENT 1 :

LINEAR MEASUREMENT

Student Name :
Student No. :

GROUP ( )

OBJECTIVE:

To familiarize the student with the types, applications of calipers, micrometers & measurements.
At the completion of this experiment, the student will be able to:

- Get familiar to the variety of the linear measurement tools, and know the type of a measurement tool needed to achieve a certain measurement.
- Students will seek more efficient means of measure.
- Take linear measurements with a certain accuracy depending on the instrument being used
- Clean, care for and store calipers, micrometers and dial indicators.

APPARATUS:

a) Vernier caliper
b) Dial caliper
c) External micrometer
d) 2-point inside micrometer

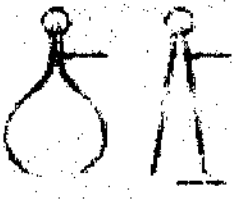
1. Calipers:

General definition of a caliper:

1. An instrument consisting essentially of two curved hinged legs, used to measure thickness and distances. Often used in the plural.

2. A large instrument having a fixed and a movable arm on a graduated stock, used for measuring the diameters of logs and similar objects.

3. A vernier caliper.



General specifications & functions of a caliper:

- All Stainless Steel construction
- Used to measure inside dimensions
- Used to measure outside dimensions
- Used to measure step dimension
- Convenient thumbscrew to lock a measurement in place
- *Accuracy equation*

$$Accuracy = \frac{1\,\text{division main scale}}{\text{no. of divisions on vernier scale}}$$

Two types of calipers are to be discussed in this experiment:

(1.1).The vernier caliper :

The Vernier Caliper shown in fig. (1.1.1) is a precision instrument that can be used to measure internal and external distances extremely accurate.

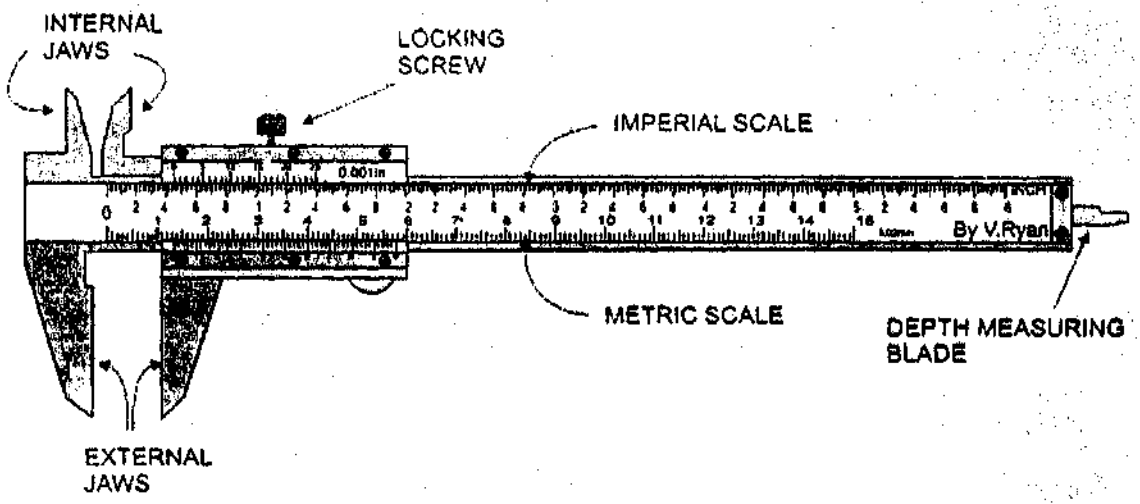


Fig. (1.1.1):a Vernier Caliper

Description:

- A vernier caliper has two scales, a *main* scale and a *vernier* scale.
- These two scales move past each other, usually on a slide.
- When the measurement is taken, the zero point of the vernier scale lies at the true datum of the measurement.
- Main scale (on the larger, fixed portion of the caliper) gives the most significant digits of your reading.
- The vernier scale (on the smaller moving portion of the caliper) gives the least significant digits in the reading and

subdivides a mark on the main scale into 10, 20, 50 subdivisions.

- Notice that ten tick marks in the sliding scale are the same width as nine ticks marks on the fixed scale.
- The smallest division on a scale is the least count of it. On the fixed scale (main scale) the least count is **1** mm, while on the sliding scale (vernier scale) the least count is **.02** mm (50 divisions to represent 1 cm).
- Most direct reading calipers have an arrow sliding blade attached to the sliding jaw. it permits the dial caliper to be used as an efficient and accurate depth gauge.

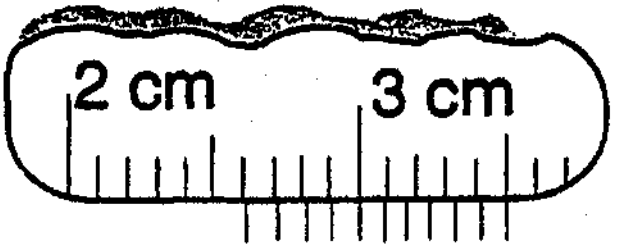
How to use &read a vernier caliper:

To start:

- Place the object between the calipers jaws.
- Close the jaws gently on the part to be measured.
- When you are measuring a round cross sectional parts, make sure that the axis of this object is perpendicular to the caliper. to ensure measuring the full diameter.
- Lock the final locking screw .and remove the object

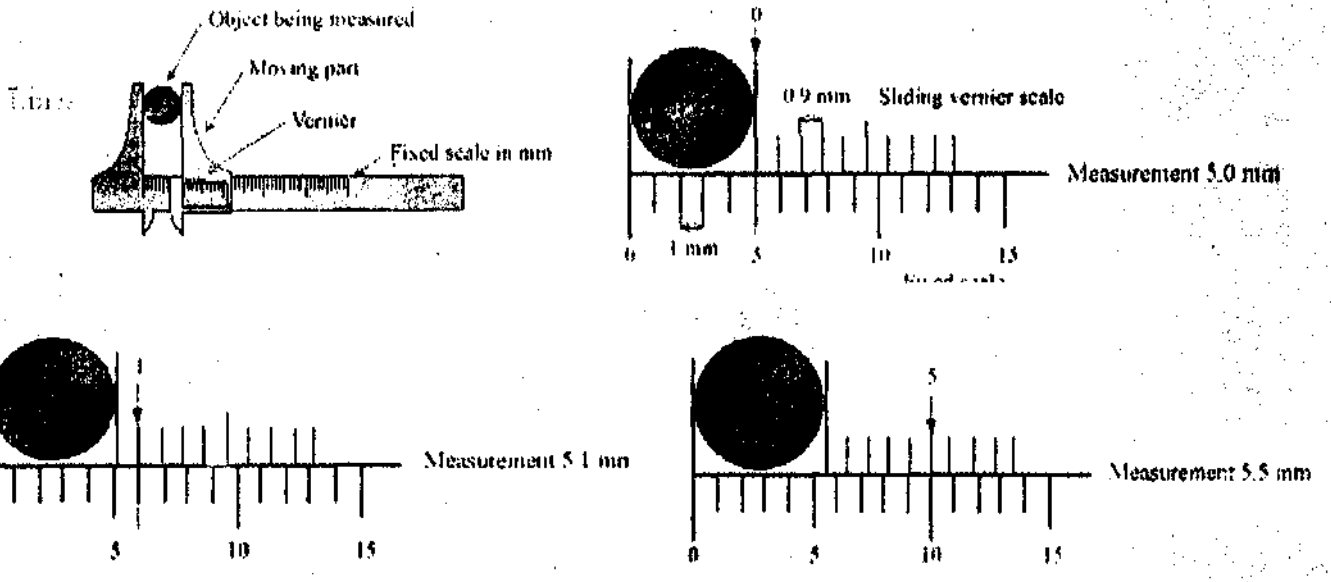
Then:

- Read the centimeter mark on the fixed scale to the left of the 0-mark on the vernier scale. (2 cm on caliper seen below).
- Find millimeter mark on the fixed scale that is just to the left of the 0-mark on the vernier scale. (2.6 cm).
- Look along the ten marks on the vernier scale and the millimeter marks on the adjacent fixed scale, until you find the two that most nearly line up. Here it is (0.04 cm).
- To get the correct reading, simply add this found digit to your previous reading. (2.64 cm).
- If two adjacent tick marks on the sliding scale look equally aligned with their counterparts on the fixed scale, then the reading is half way between two marks. If the 4^{th} and 5^{th} looked to be equally aligned with their counter parts then the reading is (26.45±.05) mm.
- If the reading is a nice number such as (2, 6, 9….etc.) don't forget to place the zero decimal after the reading plus to the error introduced (I.e. 2.000±.05).
- **Example:**



Reading: 2.64

- The vernier caliper is an extremely precise measuring instrument , the reading error is (1/20) mm=0.05 mm
- Note: for inside readings ,the thickness of the jaws must be added to the scale reading.



- Fig. (1.1.2): Further examples on using a Vernier Caliper.

(1.2)Dial caliper:

It can be described as a modified vernier caliper with gauges, which allows us to have a direct reading. It can be also provided with a digital indicator.

Because it is easier to read, the direct reading dial caliper is gradually replacing the standard vernier caliper.

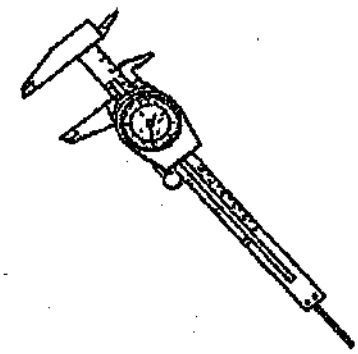


Fig. (1.2.1) :Dial Caliper

Description:

- Dial calipers are manufactured is inch &/or metric standards, and are available with digital readouts.
- A dial indicator, the hand of which is attached to a pinion is mounted on the sliding jaw.
- For metric dial caliper one revolution of the hand represents 2mm of travel, depending on the manufacturer. Therefore, each dial graduation represents .02mm maximum discrimination. Other type with 5mm move/rev & maximum of 0.05 mm.
- Most direct reading calipers have an arrow sliding blade attached to the sliding jaw (and dial).it permits the dial caliper to be used as an efficient and accurate depth gauge as introduced later
- The beam scale on the dial caliper is graduated only into 5mm and 10mm increment.
- The caliper dial is graduated into 100 dimensions.

How to use &read a dial caliper:

- Place the object between the calipers jaws.
- Close the jaws gently on the part to be measured.
- When you are measuring a round cross sectional parts, make sure that the axis of this object is perpendicular to the caliper, to ensure measuring the full diameter.
- Get the most significant digit from the main scale let us say (2.4 cm),then look at the dial gauge to take the least significant digits (as 1 division on the dial indicator equals .02 mm)so if we had 67 divisions on the dial then the least significant digit is = 67 *.02 = 1.28 mm.
- Finally to get your reading add the most and least significant , and take into considerations units, 24mm+1.28mm = 25.28mm ±0.05mm

How to care the calipers?
Regardless of what type you use:

1. Wash your hands before use.
2. Wipe the calipers components.
3. Do not drop or otherwise mishandle the caliper.

(1.3) Alignment principle:

Abbe's principle states that:
"The maximum accuracy may obtain when the standard scale and the work piece being measured are aligned on the same line measurement." When the contact points of a micrometer are away from the axis of the graduations, as shown in the example, measurement error (e) will become significant. This case, a special attention must be paid to the measuring force.

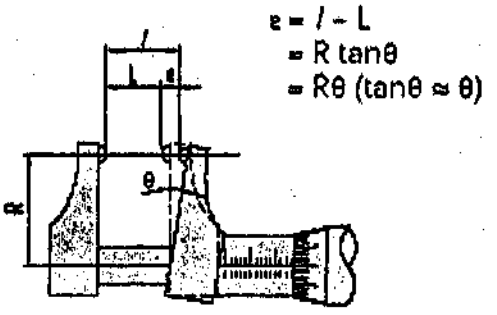


Fig. (1.3.1): abbe's principle

2.Micrometers:

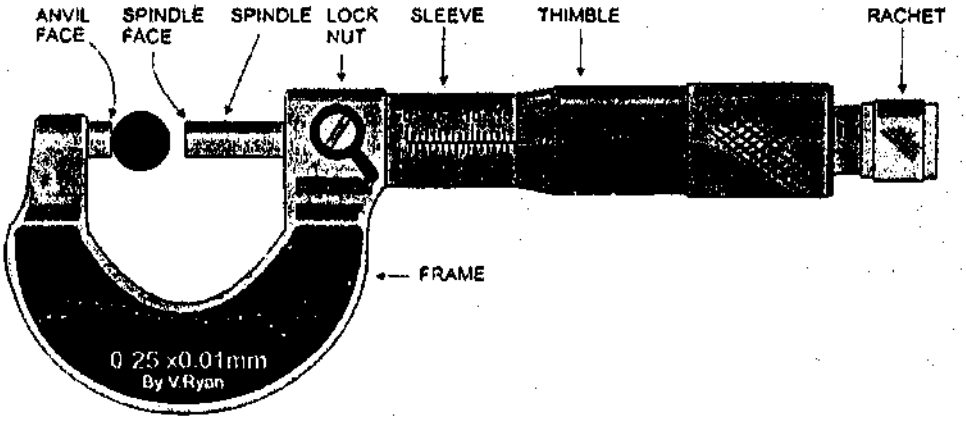


Fig.: (2.0.1): The micrometer calipers

A micrometer is a widely used device in mechanical engineering for precisely measuring thickness of blocks, outer and inner diameters of shafts and depths of slots. Micrometers have several advantages over other types of measuring instruments like the vernier, like:

- It measures greater precision than the caliper, but smaller ranges of lengths
- The vernier caliper does not give such accurate readings as micrometer because:
  1. It is difficult to obtain a correct feel due to its size and weight.
  2. The scales are difficult to read even with the aid of magnifying glass

Description:

- The tick marks along the fixed barrel of the micrometer represent halves of millimeters.
- One revolution of the knob exposes another tick mark on the barrel consequently the jaws will open another half millimeter.
- The moving barrel of the micrometer has 50 tick marks rapped around each tick mark represent 0.01 mm.
- Pitch, is the distance from point on one thread to a corresponding point on the next thread.
- Lead, is the distance to a thread advances axially in one compete revolution to turn.
- $$accuracy = pitch \times \frac{\text{no.of divs. On vernier scale}}{\text{no.of divs. On thimble scale}}$$

- Before using the micrometer, its accuracy must be verified.(as will be in the next section.).

Accuracy verification of a micrometer:

- Zero-checking:

zero checking is one way to determine the accuracy of a zero to one-2.54cm micrometer. Zero checking is exactly what it sounds like.

Zero checking is the condition where, the display of a zero to one-inch micrometer should show zero.

The steps are as follows.

1. Turn the thimble of the micrometer until the spindle is snug against the anvil.
2. Fine-tune the contact between the spindle and anvil with the ratchet stop until it clicks.
3. Check the reading.
4. If the reading is zero, the micrometer is ready to be used for measuring.

   If the reading u got does not equal zero(due to our capabilities of sight), use the following steps to correct the gage, then read the micrometer and subtract this offset from all the measurements been taken.

- Calibration:

Calibration is the process for insuring the accuracy of gages. The process involves a gage block and the micrometer. A gage block is a block made from steel that is cut to size with in a millionth of an (inch\cm). Gage blocks come in various sizes and are used to check the accuracy of measuring devices such as a micrometer.

If the reading you get from the micrometer is the gage block's dimension, you may begin using the micrometer for measuring. The micrometer may also be checked for calibration using other gage blocks within its range.

Using other blocks that fall within the range of the gage will test the gage's accuracy from one end of the spindle to the other. This may also uncover problems and explain why the gage is loosing accuracy. In the event that the display and the gage block dimension do not correspond, you will need to re-calibrate the micrometer.

Types of micrometers:

There are three types of micrometers based on their application:

- External micrometer
- Internal micrometer
- Depth micrometer

An external micrometer is typically used to measure wires, spheres, shafts and blocks.

An internal micrometer is used to measure the opening of holes, and a depth micrometer typically to measure depths of slots and steps.

How to use &read a Micrometer:

To start:

- Use the ratchet knob (cap) to close the jaws gently on the object to be measured. When the ratchet clicks the jaws are closed sufficiently.

Then:

To read the distance between the jaws of a micrometer:

- Get the reading from the fixed barrel ,while(1 div. = .5 mm), divisions
- Get the reading of the moving barrel while (1 div. = .01 mm)
- To get the final reading simply add the two reading, and take into consideration the units

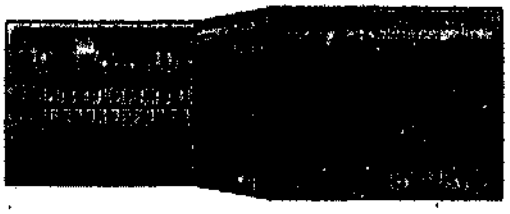
Using Fig. (2.0.1) seen below:

1. Read the scale on the sleeve. The example clearly shows12 mm divisions.

2. Still reading the scale on the sleeve, a further ½ mm (0.5) measurement can be seen on the bottom half of the scale. The measurement now reads 12.5mm.

3. Finally, the thimble scale shows 16 full divisions (these are hundredths of a mm).

The final measurement is 12.5mm + 0.16mm = 12.66 ± 0.005 mm



SLEEVE READS FULL mm = 12.00
SLEEVE READS ½ mm = 0.50
THIMBLE READS = 0.18
TOTAL MEASUREMENT = 12.68mm

Fig. (2.0.1)

How to care the micrometers:

- Before work makes sure that the object to be measured is fixed stationary (not moving).
- Avoid over tightening the micrometer. Such abuse to the micrometer will only do damage to the micrometer, or any other gage you may be using.
- Great care must be taken in using the micrometer caliper; A ratchet knob is provided for closing the caliper on the object being measured without exerting too much force.
- While you are using a micrometer, it would be mostly recommended to hold the frame with one hand and turning the knurled sleeve with the other hand.
- Damage can be caused to a micrometer if it is dropped. So it is recommended to make sure that the micrometer is in a safe place when it is not being used.
- Before you store a micrometer back the spindle away from the anvil wipe all exterior surfaces with a clean glove.

(2.1)THE DEPTH GAUGE MICROMETER:

Definition:

The depth gauge micrometer is a precision measuring instrument, used by engineers to measure depths of holes, slots, and recesses, the distance of stepped faces from each other and similar applications.

Description:

- Each revolution of the ratchet moves the spindle face 0.5mm towards the bottom of the blind hole.
- **Fig (2.1.1)** below shows how the depth gauge is used. The ratchet is turned clockwise until the spindle face touches the bottom of the blind hole. The scales are read in exactly the same way as the scales of a normal micrometer. (Refer to the example about fig (2.0.1).

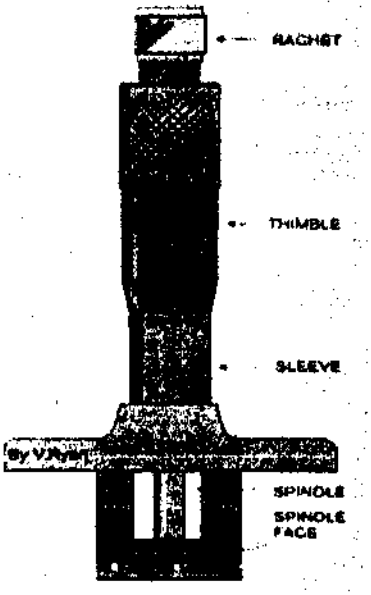


Fig (2.1.1): depth-gauge micrometer

(2.2) two-point inside micrometers

this micrometer is used for measuring the internal dimensions and graduated in 100's of a mm, this micrometer is available in two designs: fig(2.2.1)

1. One with jaws similar to vernier caliper and with a scale reading backwards.
2. The second is a straight bar with a micrometer barrel this type can b obtained with several interchangeable rods which allow a wide range of measurements.

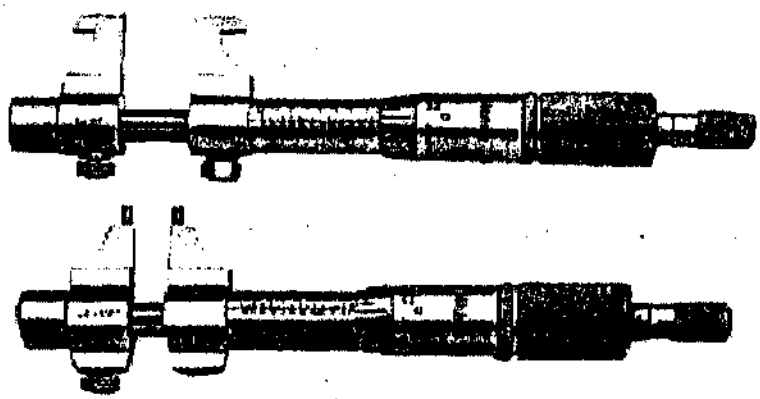


Figure (2.2.1): 2-point inside micrometer

Description:

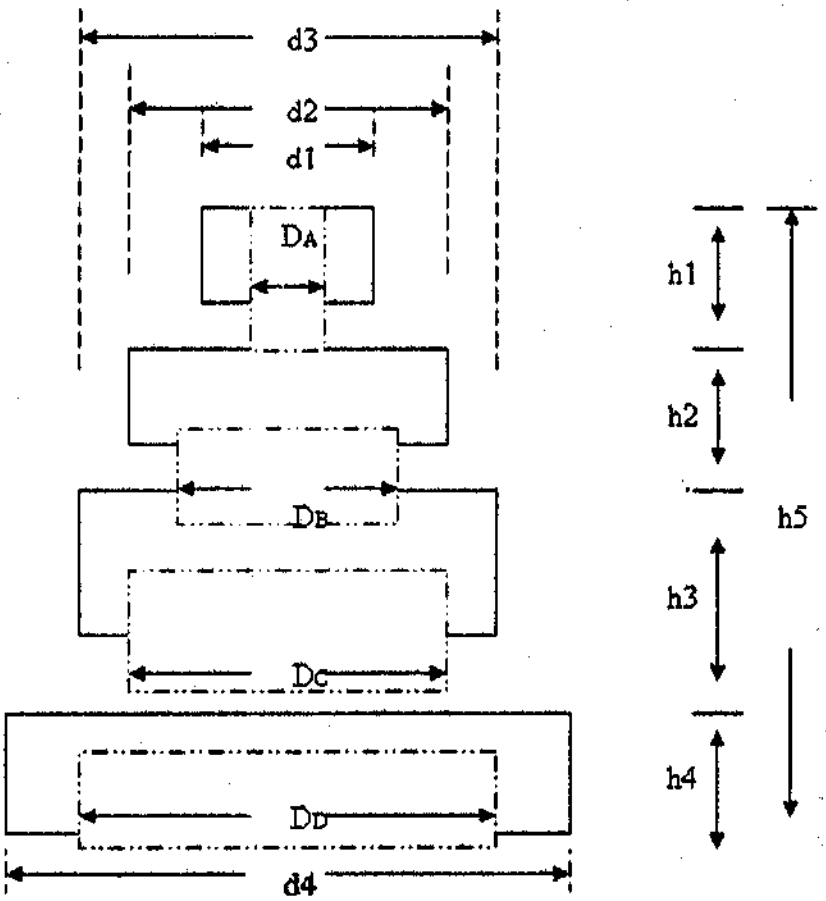
- This type of micrometer used for measuring inside diameters.
- The same principle application as for other micrometer.
- The reading of two point inside micrometer is taken in a similar manner are that of the depth micrometer.
- The reading increase as the thimble is screwed.

PROCEDURE:

- Inspect the tool to be used before using.
- Check its accuracy and zero alignment.(determine an offset).
- Clean the specimen to be used, with a soft cloth.
- Hold the tool in a proper way to start measuring.
- Take abbe's principle into consideration before taking a reading.
- Measure the dimensions of the specimen shown below with each of the following measuring devices (If it is possible):

  Vernier Caliper, Dial Caliper outside micrometer, 2-point inside micrometer &depth micro meter
- Make sure not to drop the measuring tool.
- Record you readings in table 1

- After measurements are taken ,make sure to leave the measuring device clean, and in a safe place



RESULTS:

Measuring instrument	D1	D2	D3	D4	Da	Db	Dc	Dd	H1	H2	H3	H4	H5
Vernier caliper													
dial													
Outside micrometer													
2-point depth													

Table 1

DISCUSSION & CONCLUSIONS :

Caliper:

1. Does the vernier caliper conform to abbe's principle of alignment? Why?

2. Calculate the error of a vernier caliper?

3. What is the function of the sliding blade of the caliper?

4. what is a direct reading instrument, does that apply to the caliper?

5. What are the sources of error in reading a caliper?

6. What could happen if the locking screw is not used when measuring a distance with the vernier caliper?

7. Is the reading taken from a caliper in an inside measurement of an object is final? In this case is the caliper considered to be a comparator?

8. Is the vernier line standard or end standard?

9. What are the advantages of the vernier caliper over the micro meter?

Micrometers:

1. Draw a simple diagram representing the depth gauge micrometer and label the important parts.

2. How many screw threads are in each micrometer?

3. Does the external micrometer Obeys the abbe's principle? How?

4. What is the total length approached by the moving barrel when it rotates a complete revolution?

5."over tightening the micrometer, will only do damage to the micrometer, or any other gage you may be using." Explain.

4. Can this micro. Be used as comparators?

5. the accuracy of the micrometer depends on the accuracy of the screw threads, explain?

6. What are the factors governing the estimated reading?

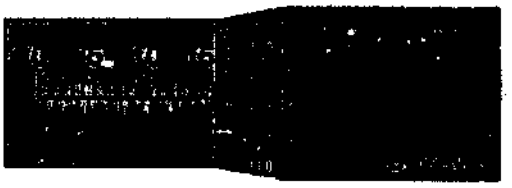
7. What are the sources of error in reading a micrometer?

8. Is the spindle rotating or non rotating type? Name disadvantages of rotating type?

EXTRA EXCERSISES:

1. What s the reading indicated by the following micrometers?

answer:

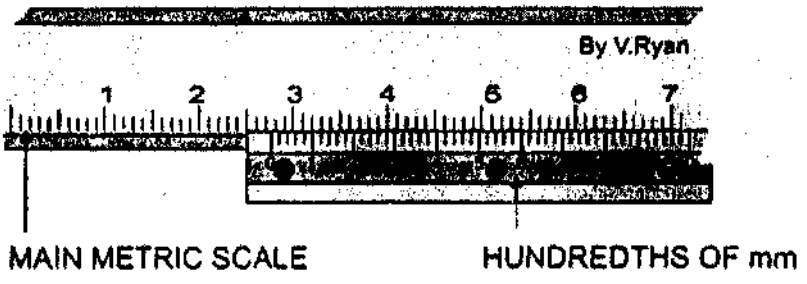


answer:

answer:

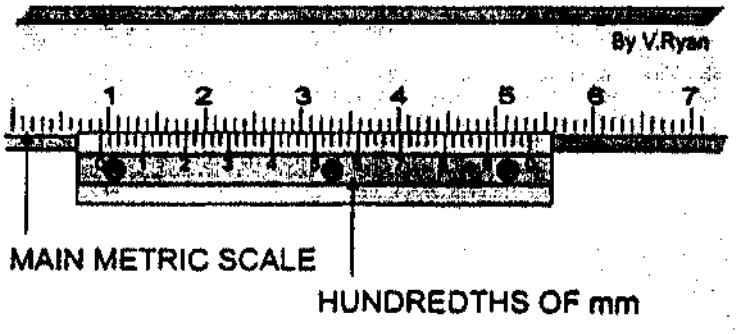
2. What s the reading indicated by the following calipers?

QUESTION 1:



answer:

QUESTION 2:



answer: