Certificate in Metal Machining (1155-01-015)

MEASURING AND MARKING

OBJECTIVE

The Objective of this section is to enable the trainee to:
Choose, maintain and use the most suitable marking out and measuring equipment.

Contents

Task No.	Knowledge requirements
7.1	Identify and describe the use of marking out and measuring equipment, tools and instruments.
7.2	Compare the relative degrees of accuracy of marking out and measuring equipment listed.
7.3	Identify methods of marking out.
7.4	Identify datum and describe methods of marking out from them.
7.5	Describe how to avoid faults and minimize inaccuracies when marking out
7.6	Identify and describe the operation of tools and equipment for angular marking out and measurement.
7.7	Identify and explain the use of the precision bubble level to establish horizontal and vertical planes.
7.8	Identify and explain the use of the plumb bob to establish vertical planes.
7.9	Identify template materials for given situations and describe their use.
7.10	Identify and explain the main classes of fit.

OBJECTIVE

7.1	Identify and describe the use of marking out and measuring equipment, tools and instruments.

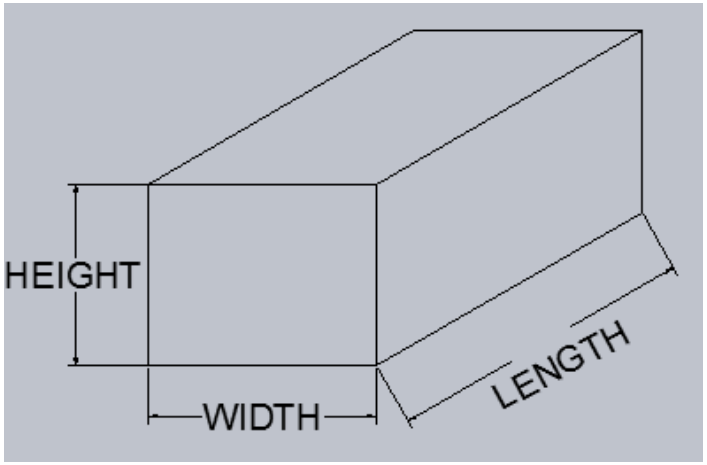
Concept of Measurement

A measurement is a comparison to a standard.

Measurement is the process or the result of determining the magnitude of a quantity, such as length or mass, relative to a unit of measurement, such as a meter or a kilogram.

For example length, width , depth , height , temperature , density etc.

Metrology is the science of measurement.

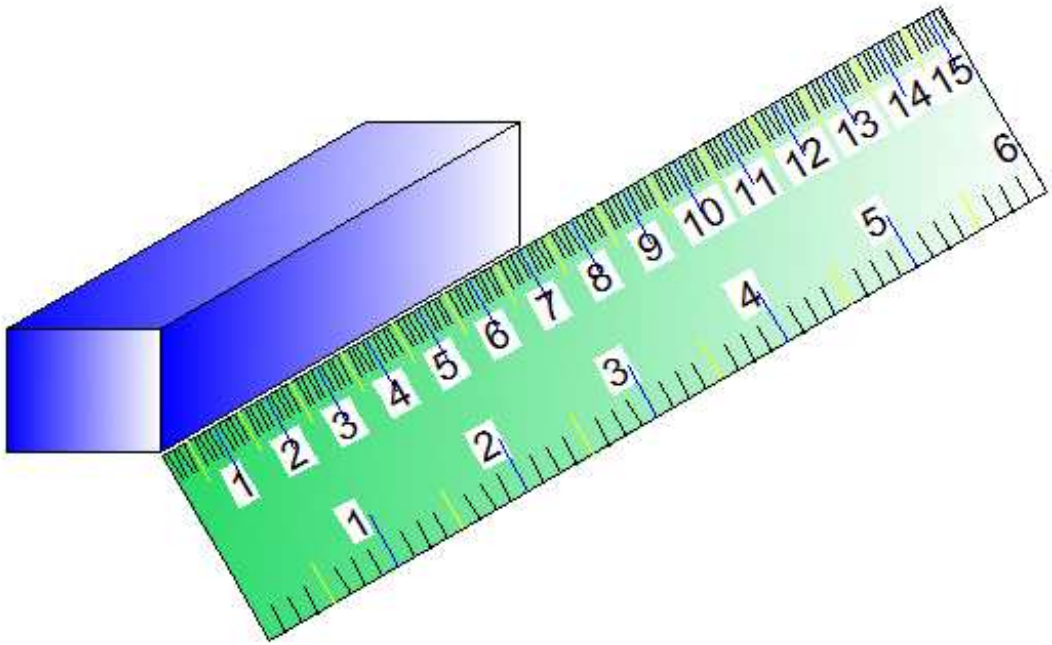


Units of Measurement

1.Metric System

The metric system is a decimal system of measurement based on its units.

A. Length is measured in meter (m), centimeter (cm), or millimeter (mm) etc.



Units of Measurement

1.Metric System

B. Mass is measured in kilogram (kg) or grams (gm)

Units of Measurement

1.Metric System

C. Time is measured in second (s), minute (min) or hour (hr)

Units of Measurement

1.Metric System

D. Temperature is measured in degree centigrade (^{0}C)

Units of Measurement

2.S.I. System

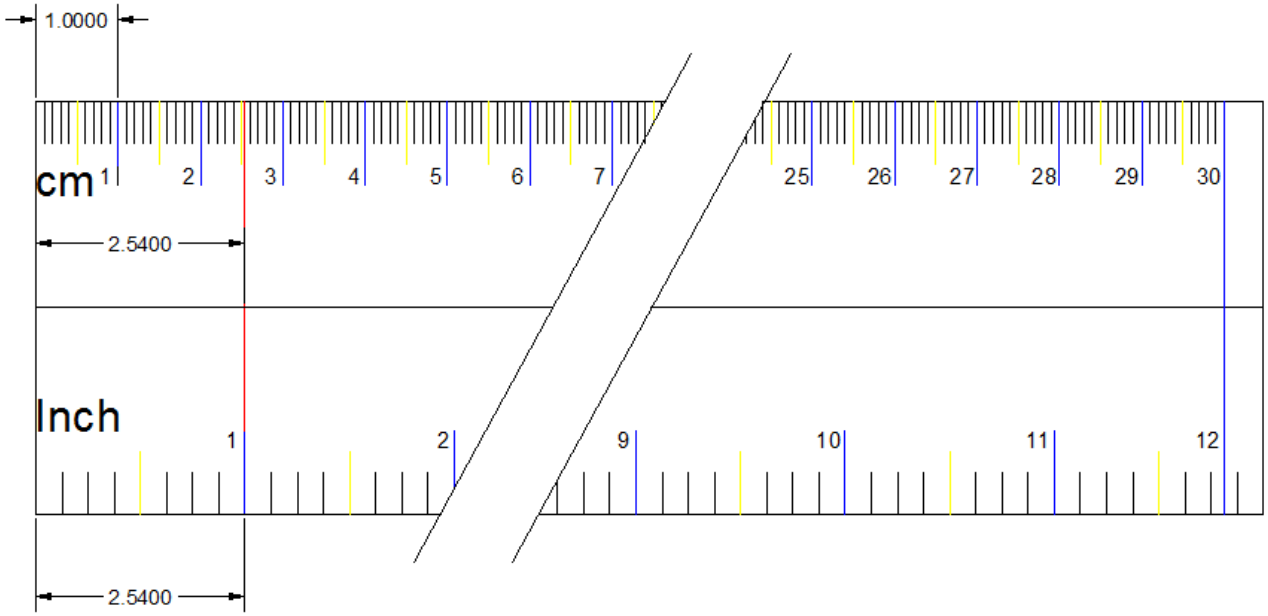
The International System of Units is the modern revision of the metric system. It is the world's most widely used system of units, both in everyday commerce and in science.

SI unit of length meter (m)
SI unit of mass kilogram (kg)
SI unit of time second (s)
SI unit of temperature Kelvin (K)

Measuring Tools

1.Ruler

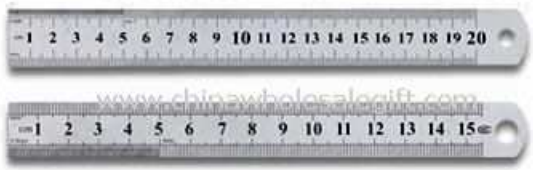
A ruler, sometimes called a rule or line gauge, is an instrument used in geometry, technical drawing, printing and engineering to measure distances and/or to rule straight lines.



Measuring Tools

1.Ruler

Desk rulers are used for three main purposes: to measure, to aid in drawing straight lines and as a straight guide for cutting and scoring with a blade. Practical rulers have distance markings along their edges.



Measuring Tools

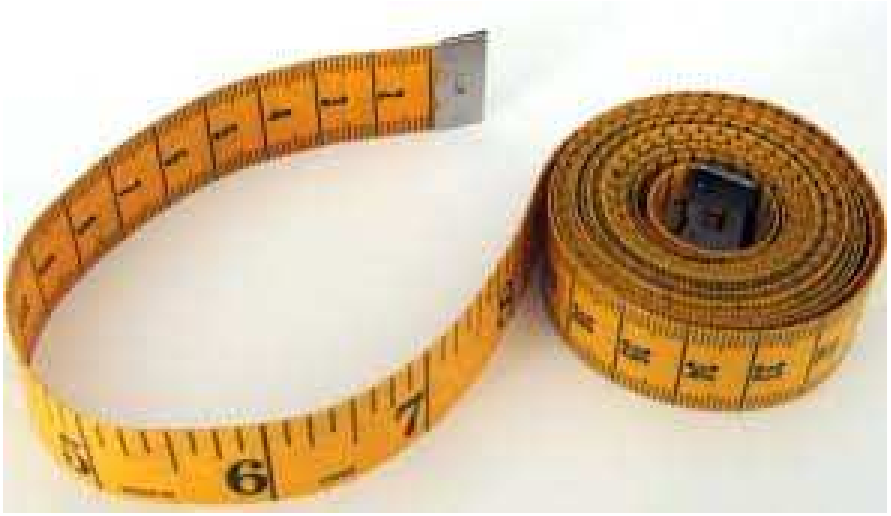
2.Measuring Tape

A measuring tape is a flexible form of ruler.

Measuring Tools

2.Measuring Tape

It consists of a ribbon of cloth, plastic, or metal strip with linear-measurement markings. It is a common measuring tool. Its flexibility allows for a measure of great length to be easily carried in pocket or toolkit and permits one to measure around curves or corners.



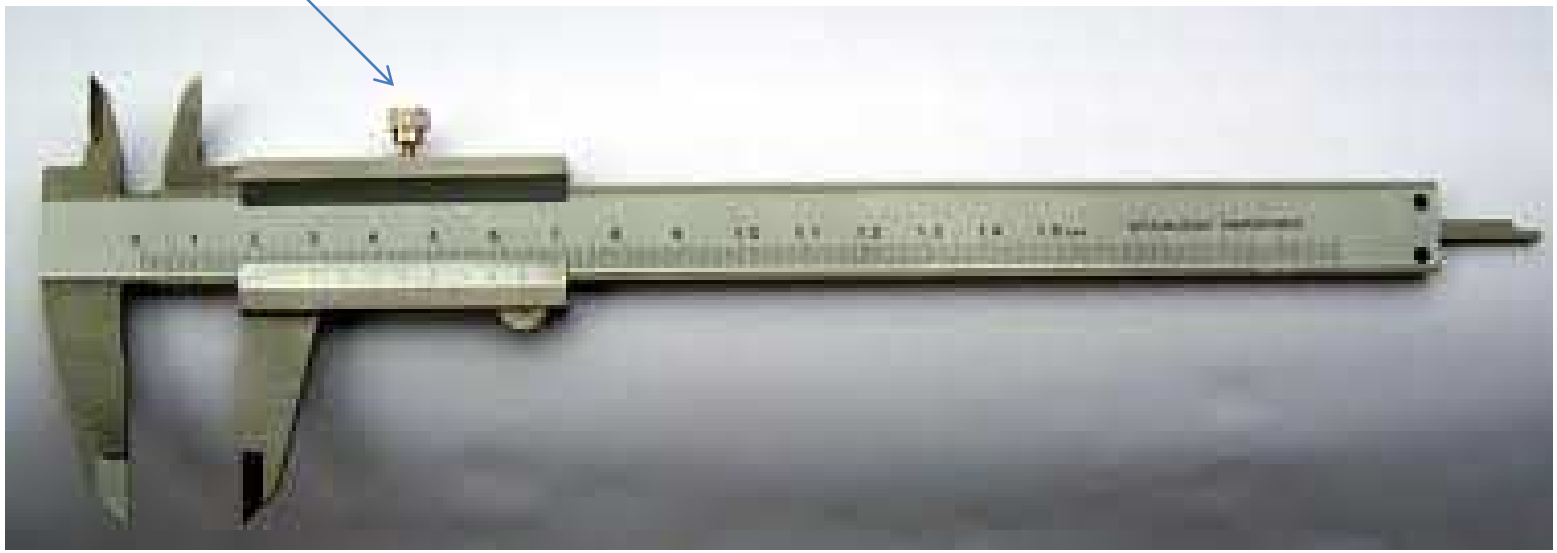
Measuring Tools

3. Vernier Caliper

A Vernier caliper is precision measuring tool.

We can measure inside, outside and depth.

It has locknut which is very useful to keep the measurement permanently.



Measuring Tools

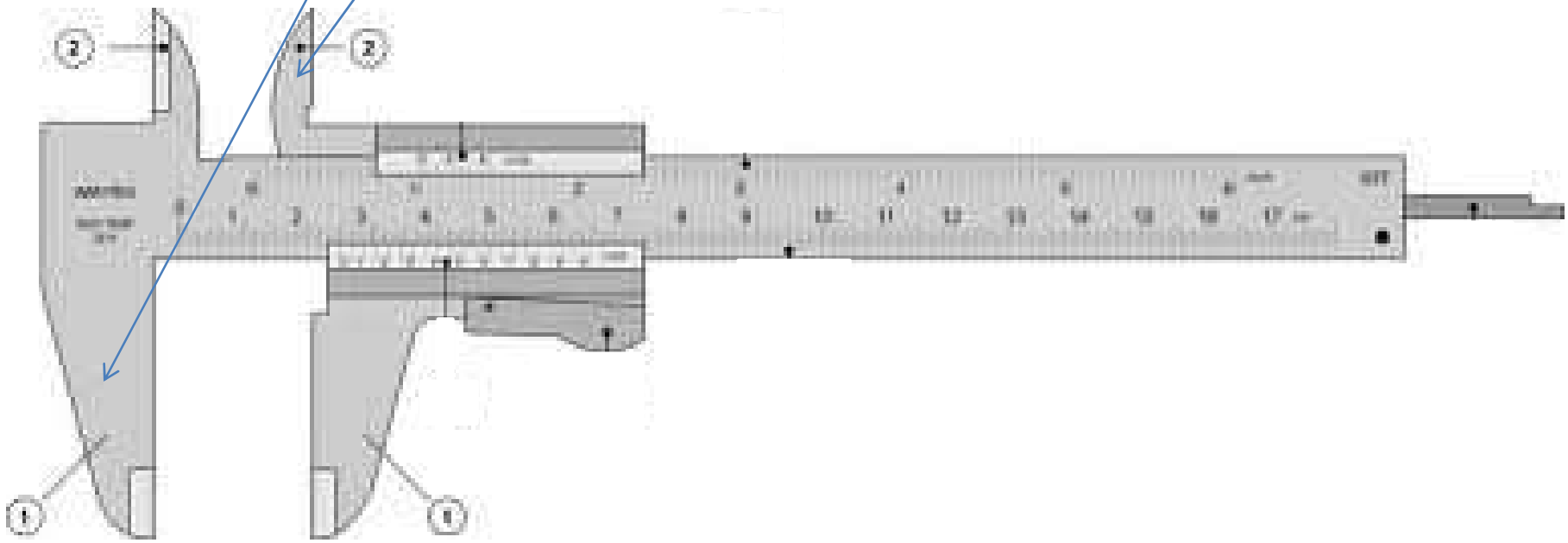
3. Vernier Caliper

Measuring Tools

Parts of Vernier Caliper

Outside jaws: (1) used to measure external diameter or width of an object.

Inside jaws: (2) used to measure internal diameter of an object.

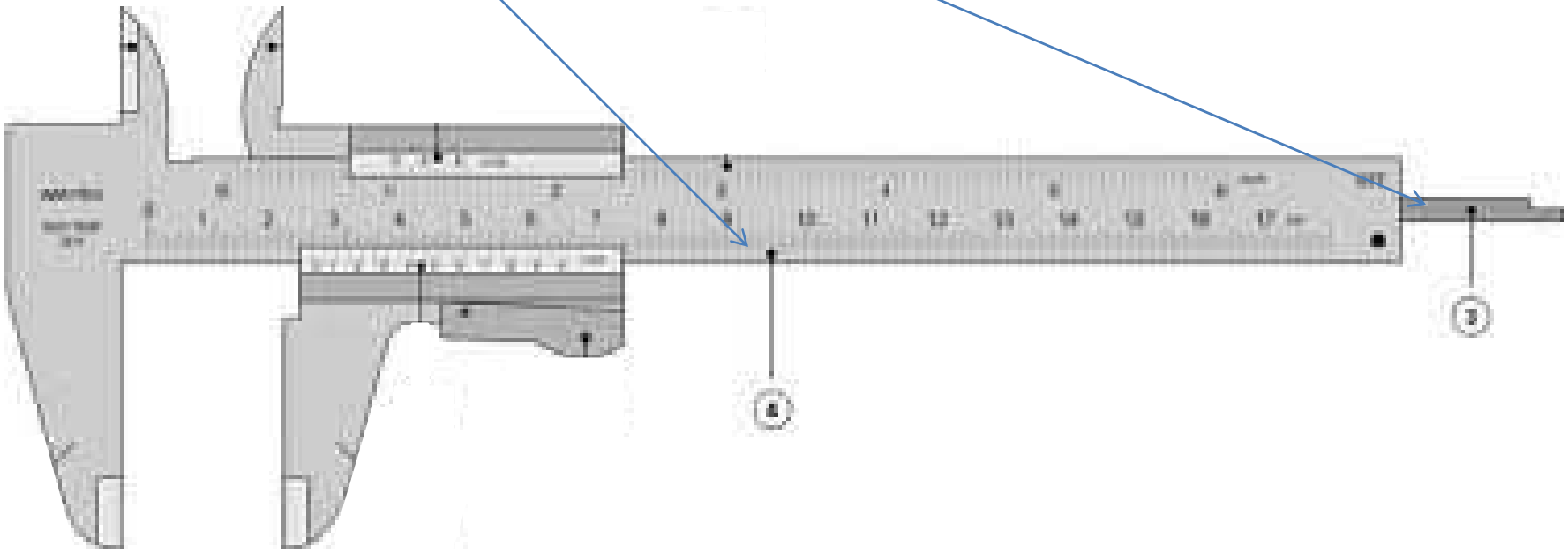


Measuring Tools

Parts of Vernier Caliper

Depth probe: ③ used to measure depths of an object or a hole.

Main scale: ④ scale marked every mm.

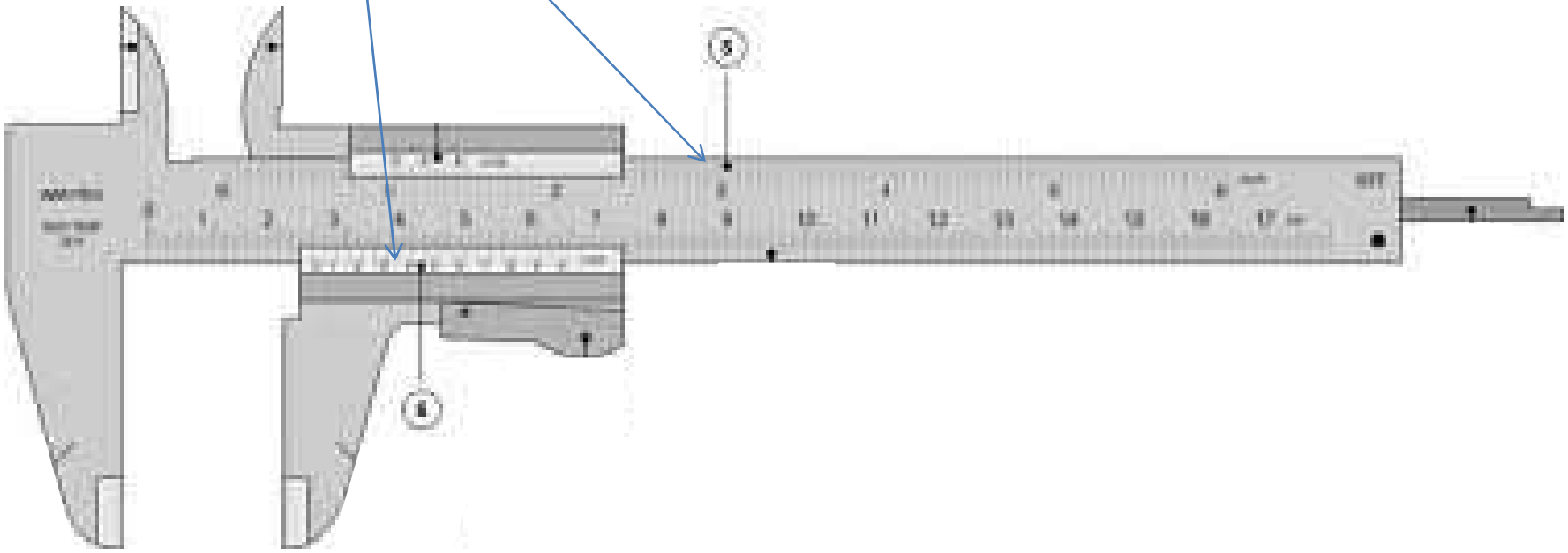


Measuring Tools

Parts of Vernier Caliper

Main scale: (5.) scale marked in inches and fractions.

Vernier : (6.) gives interpolated measurements to 1/10 mm or better.

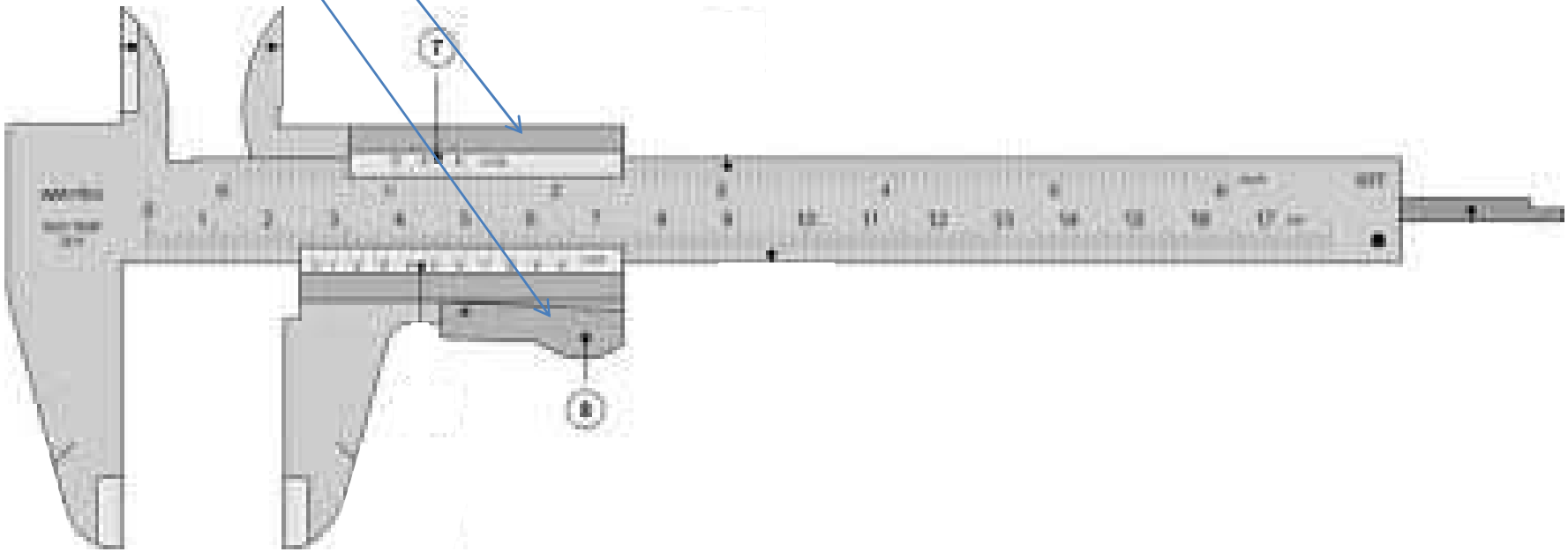


3. Measuring Tools

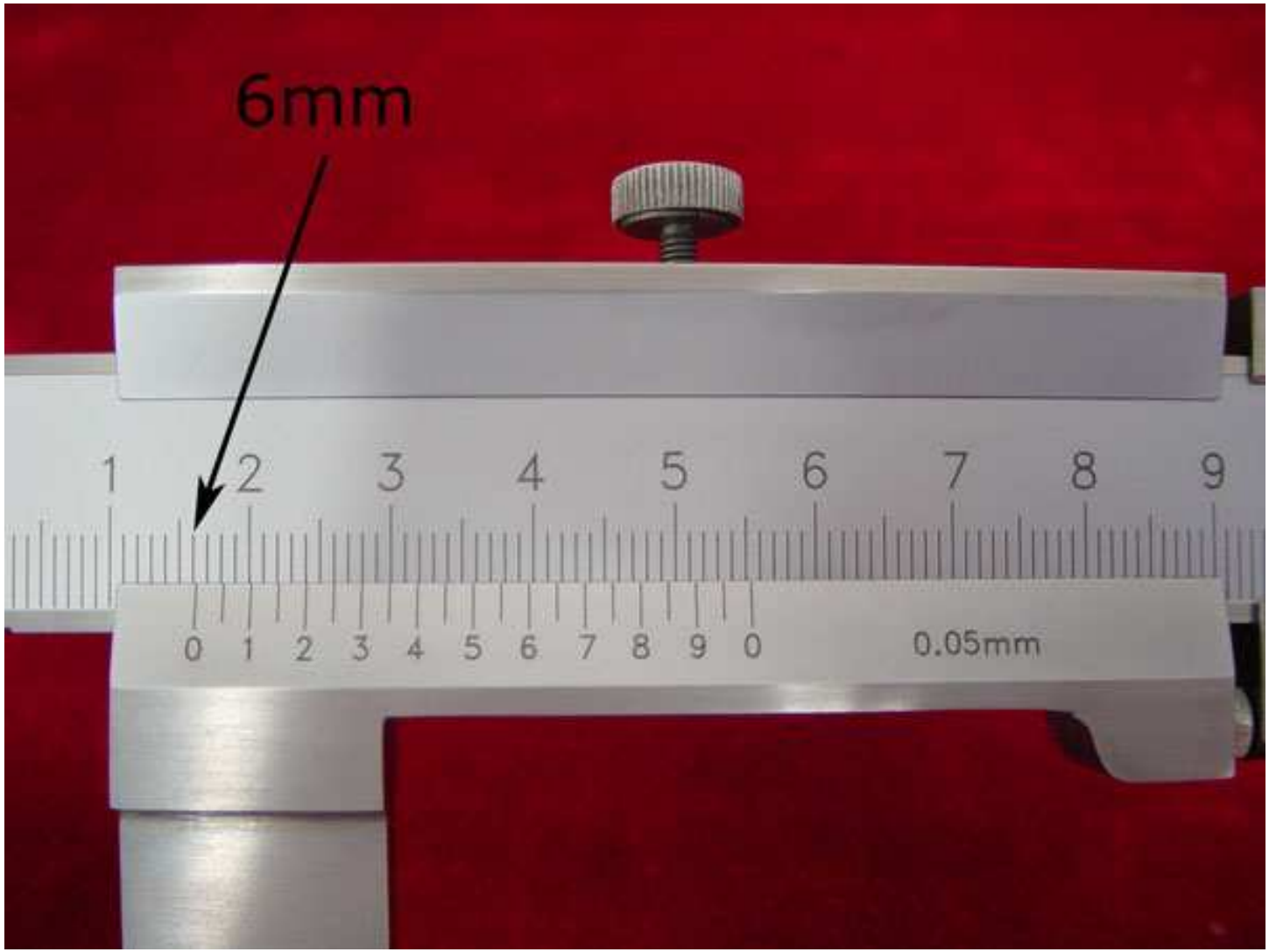
Parts of Vernier Caliper

Vernier : (7) gives interpolated measurements in fractions of an inch.

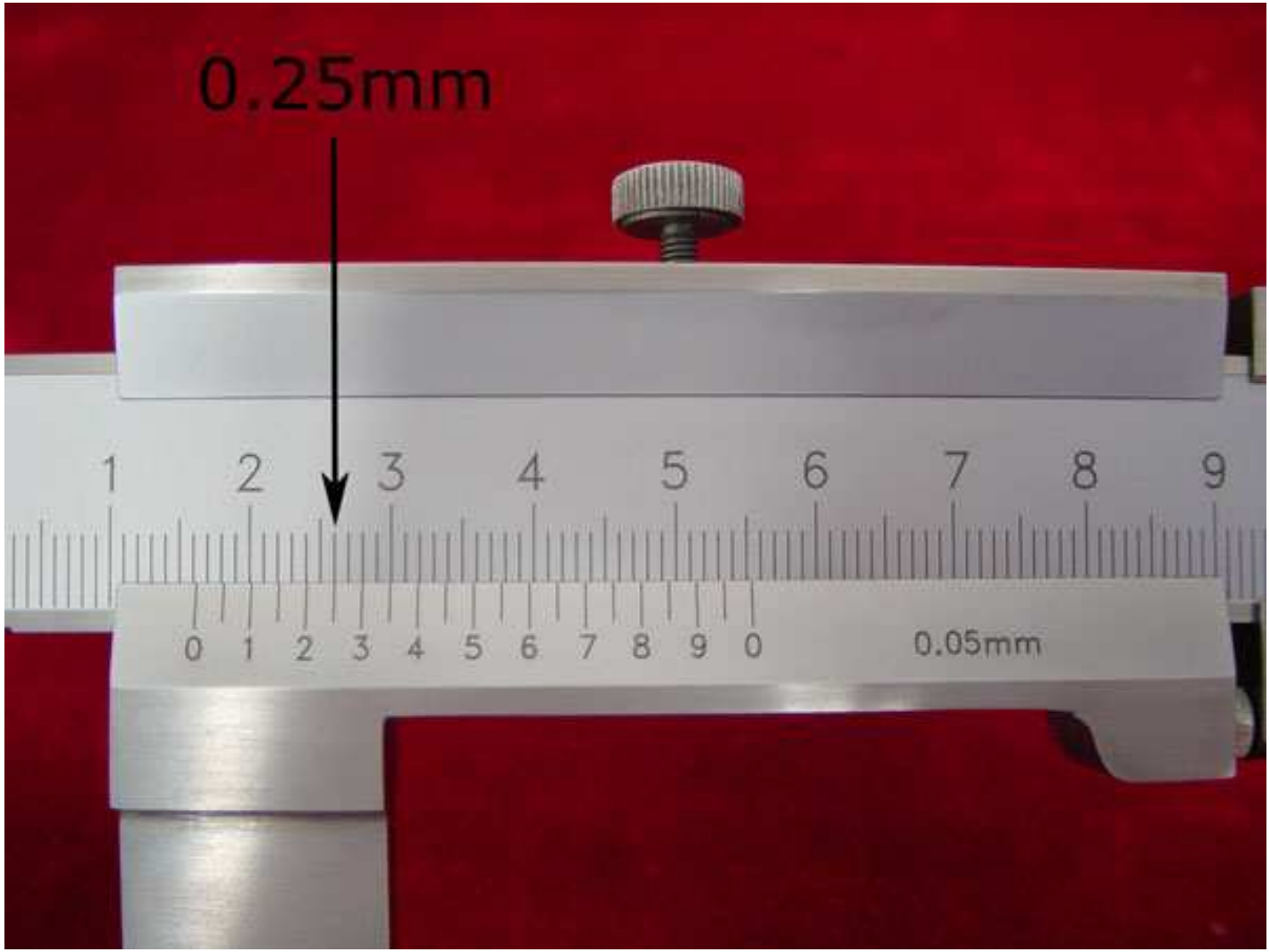
Retainer: (8) used to block movable part to allow the easy transferring of a measurement.



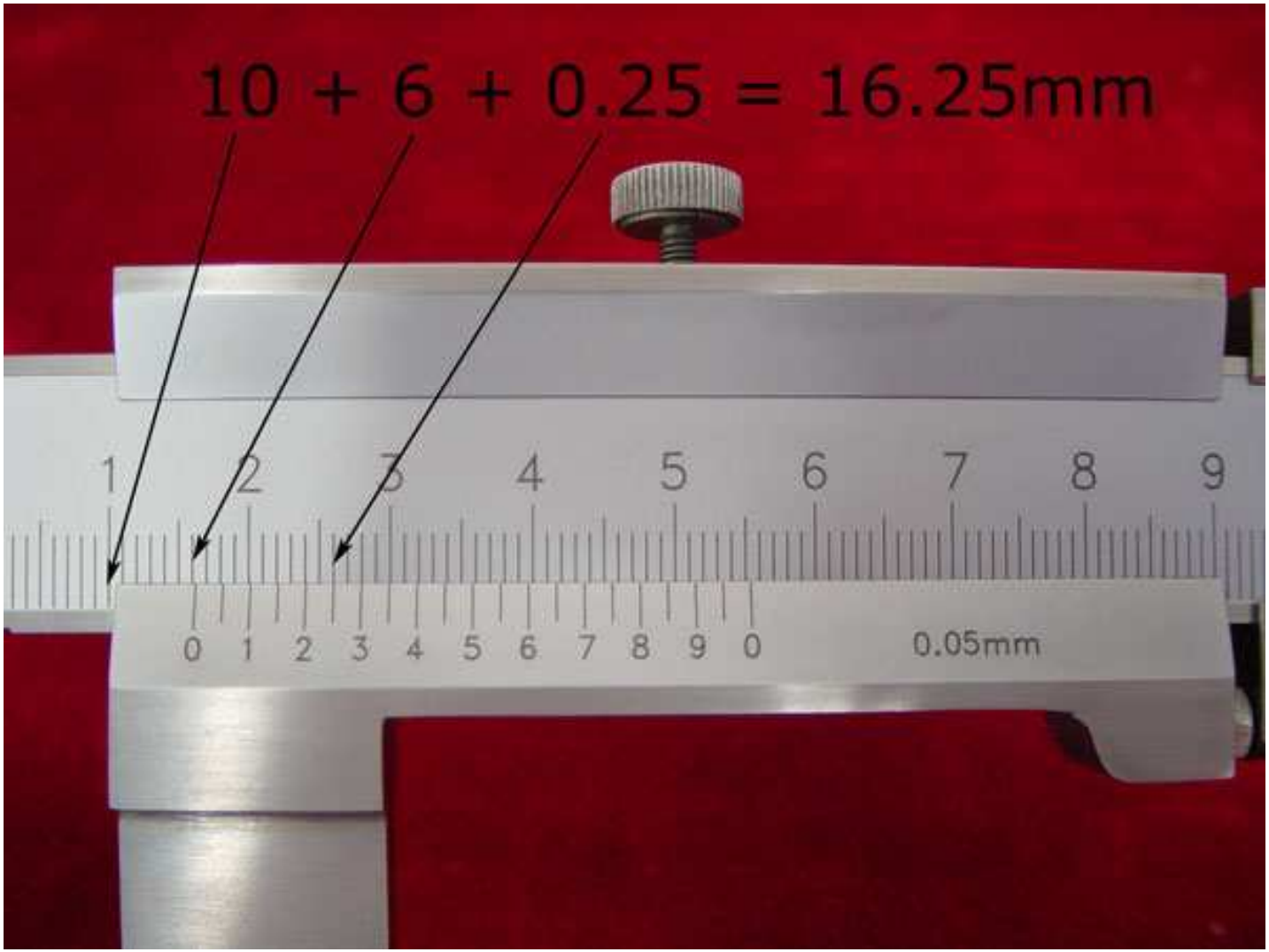
Reading Vernier Caliper



Reading Vernier Caliper



Reading Vernier Caliper



Measuring Tools

4. Micrometer

A micrometer is also called micrometer screw gauge.

It is used for precise measurement.

The least count of Micrometer is 0.001 mm

Measuring Tools

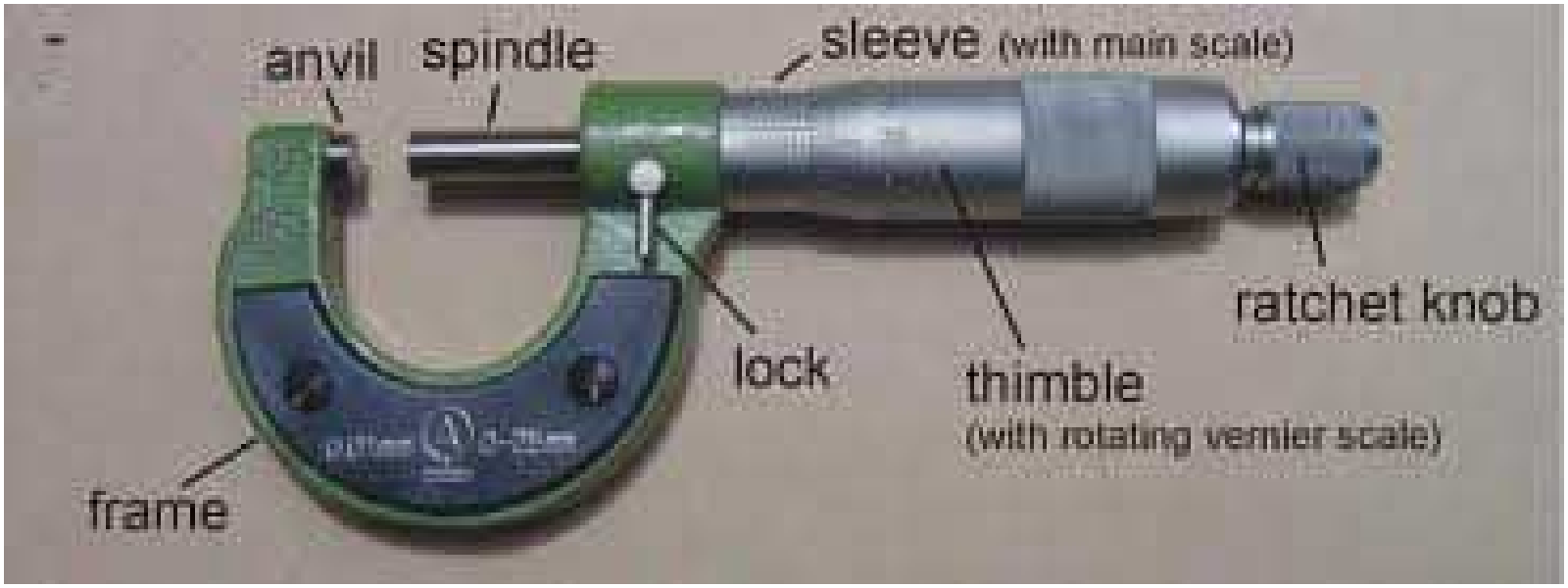
4. Micrometer

Measuring Tools

Parts of Micrometer

Frame : The C-shaped body that holds the anvil and barrel.

Anvil : The shiny part that the spindle moves toward, and that the sample rests against.

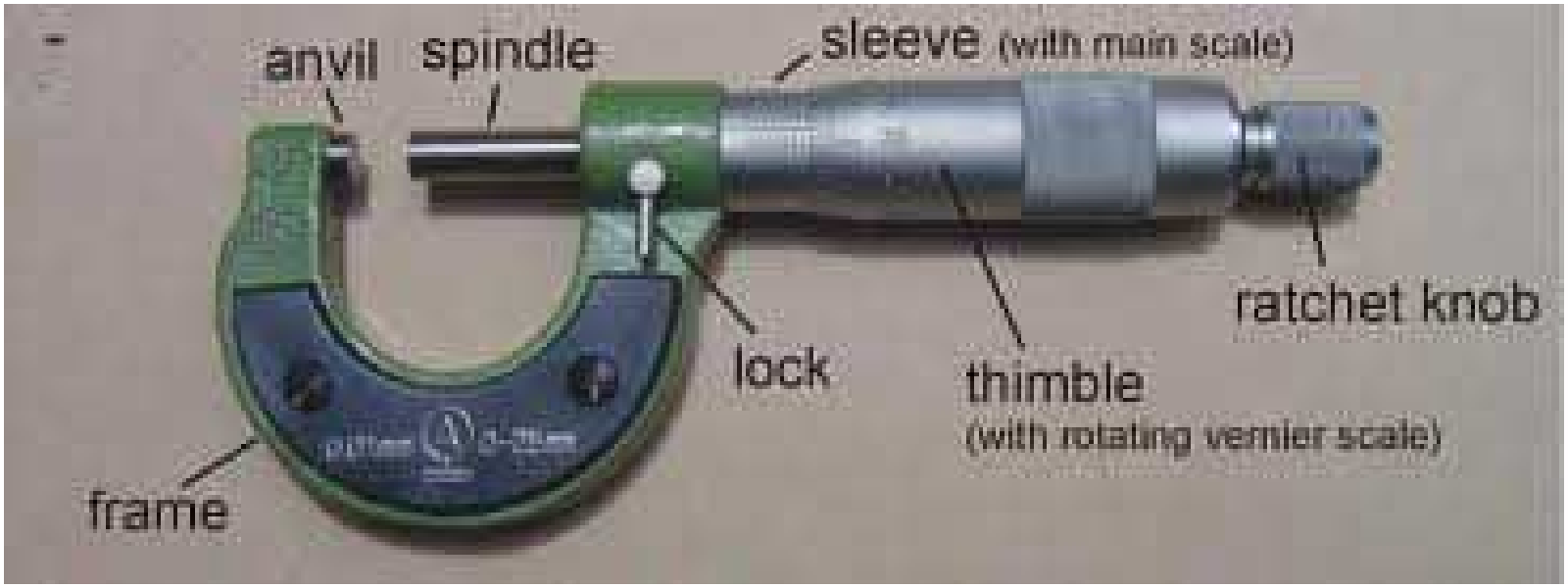


Measuring Tools

Parts of Micrometer

Thimble : The part that one's thumb turns. Graduated markings.

Thimble lock : The knurled part that one can tighten to hold the spindle stationary.

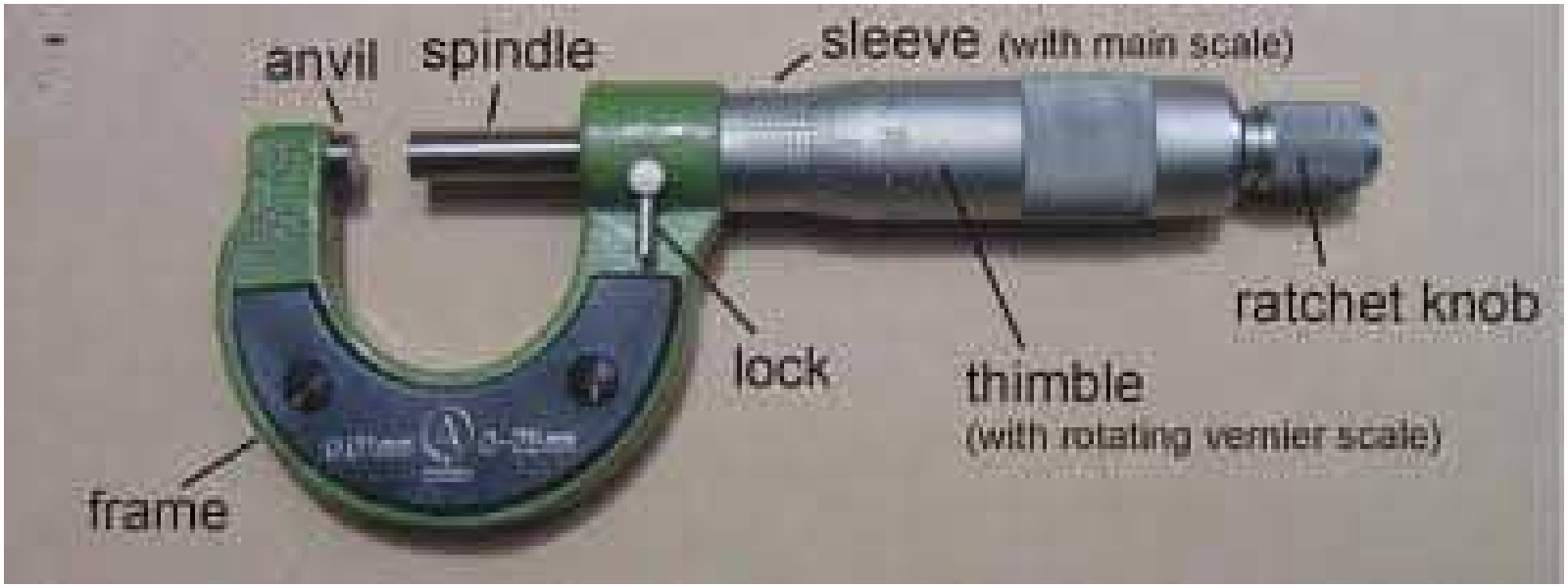


Measuring Tools

Parts of Micrometer

Spindle : The shiny cylindrical part that the thimble causes to move toward the anvil

Sleeve : The stationary round part with the linear scale on it. It is also called barrel or stock.



Measuring Tools

Types of Micrometer

The names are based on their application:

A. Outside micrometer

These are typically used to measure wires, spheres, shafts and blocks.

Measuring Tools

Types of Micrometer

B. Inside micrometer

Used to measure the diameter of holes.

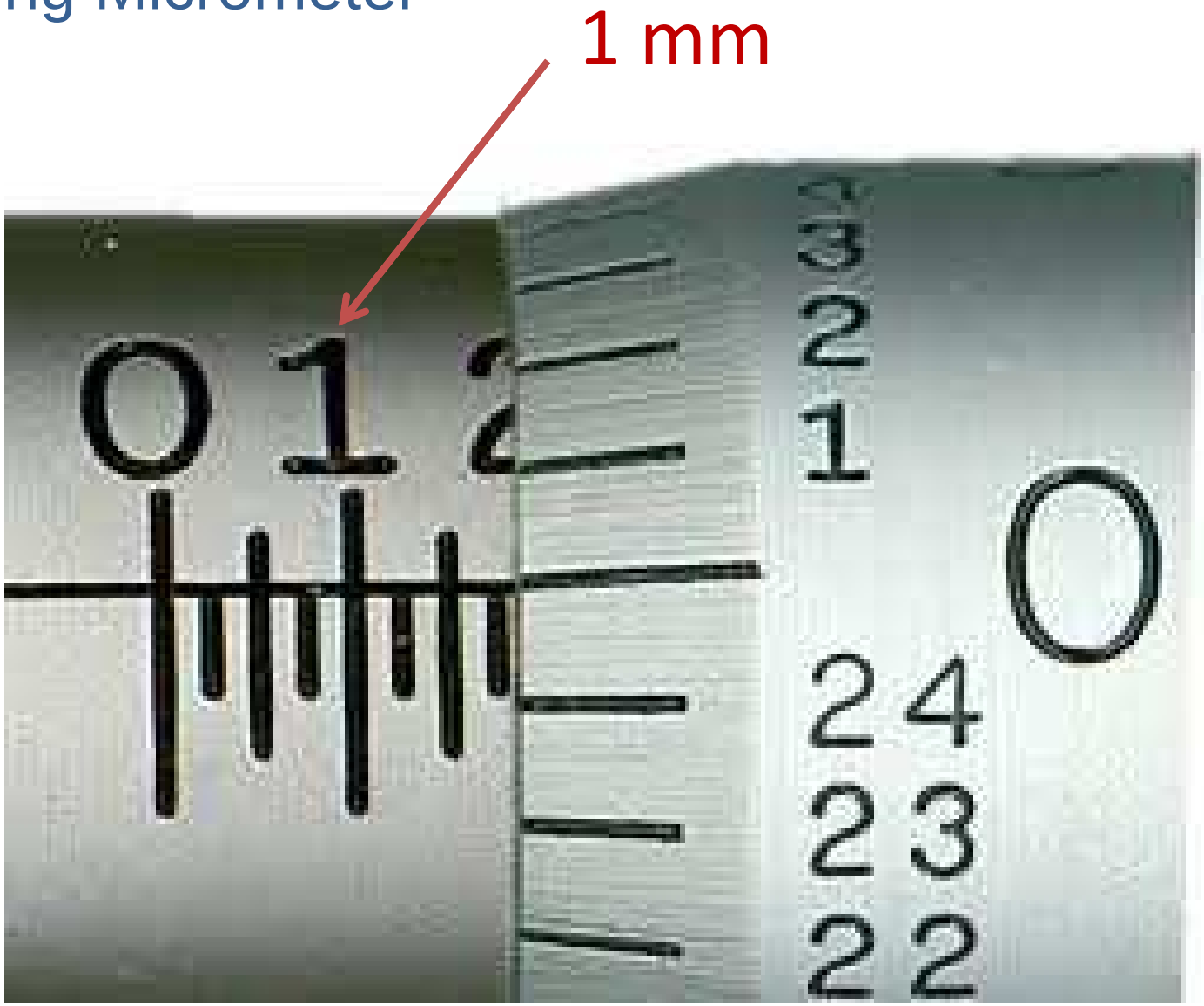
Measuring Tools

Types of Micrometer

C. Depth micrometer

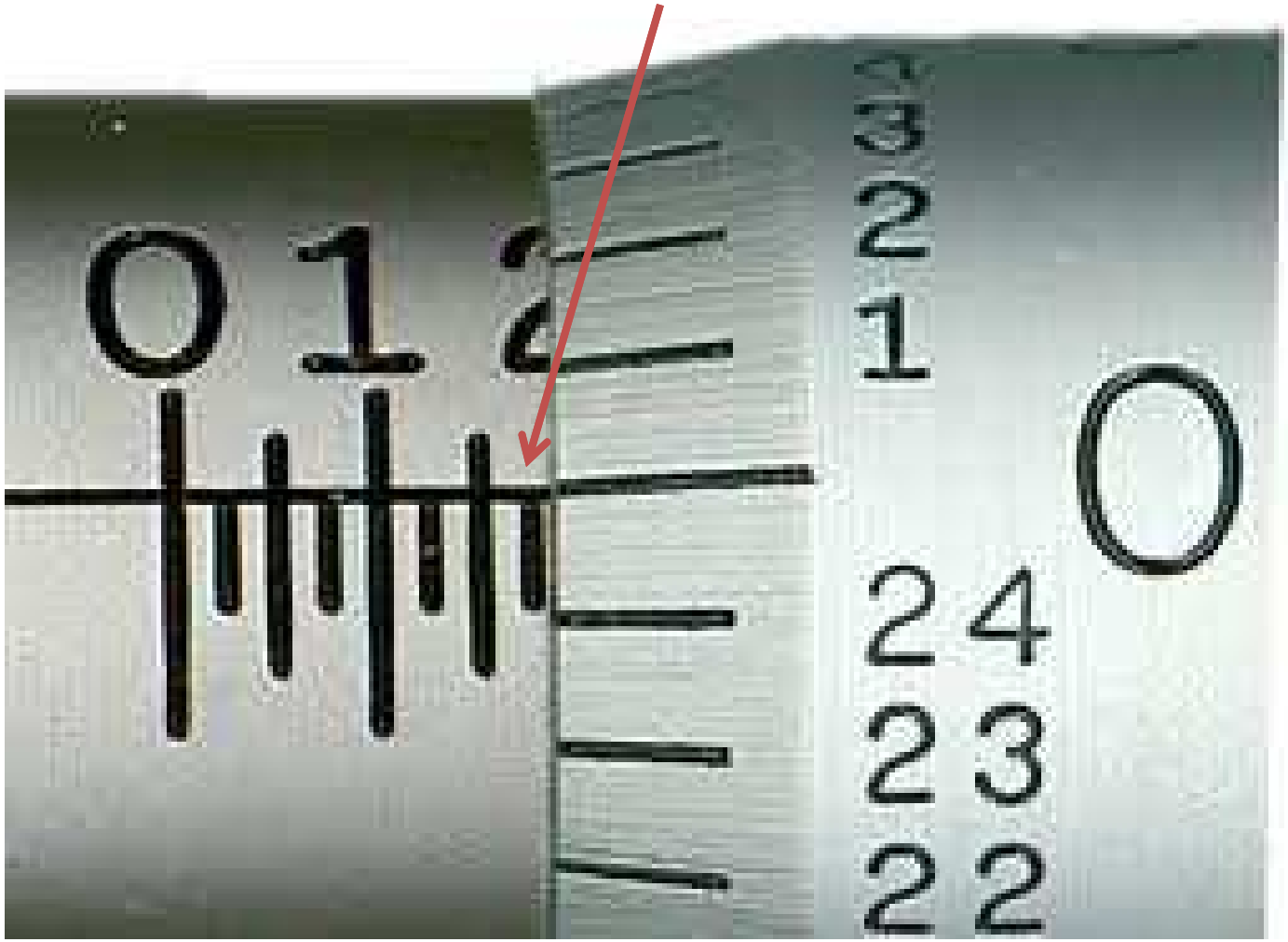
Measures depths of slots and steps.

Reading Micrometer



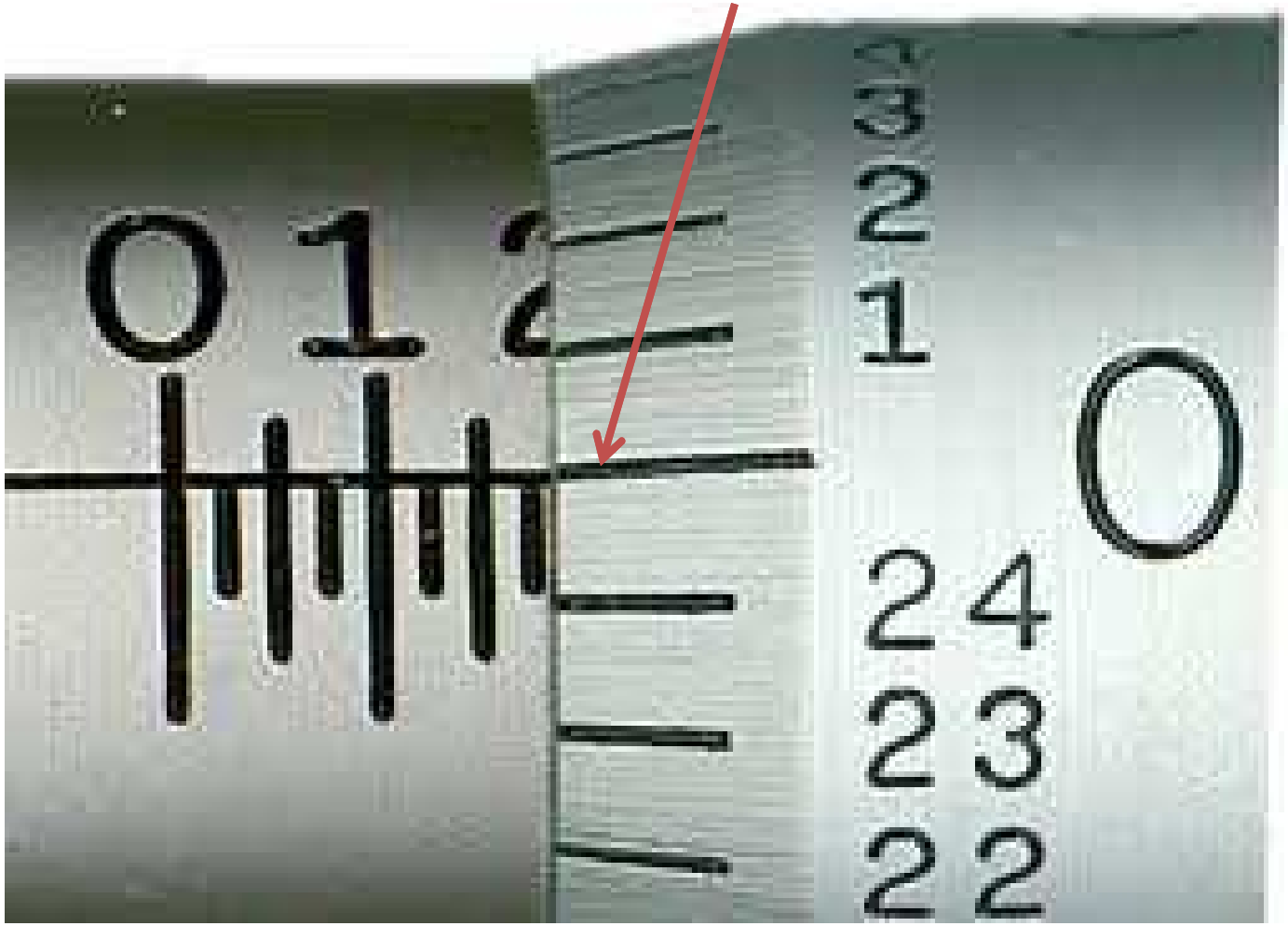
Reading Micrometer

1+0.75 mm



Reading Micrometer

1+0.75+0=1.75mm



Measuring Tools

5. Height gauge

A height gauge is a measuring device used either for determining the height of something, or for repetitious marking of items to be worked on.

Measuring Tools

5. Height gauge

This measuring tool is used in metal working or metrology to either set or measure vertical distances.

Measuring Tools

6. Feeler gauge

A feeler gauge is a simple tool used to measure gap widths. Feeler gauges are mostly used in engineering to measure the clearance between two parts.

Measuring Tools

6. Feeler gauge

(i) They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece.

(ii) They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values.

Measuring Tools

7. Thread gauge

A thread pitch gauge, also known as a screw pitch gauge or pitch gauge, is used to measure the pitch or lead of a screw thread.

Measuring Tools

7. Thread gauge

(i) Is used as a precision measuring instrument.
(ii) Allows the user to determine the profile of the given thread.
(iii) Allows to categorize the thread by shape and pitch.

Measuring Tools

8. Slip gauge

It is used as a reference for the setting of measuring equipment used in machine shops, such as micrometers, calipers, and dial indicators (when used in an inspection role).

A slip gauge also known as a gage block, a precision ground and lapped length measuring standard.

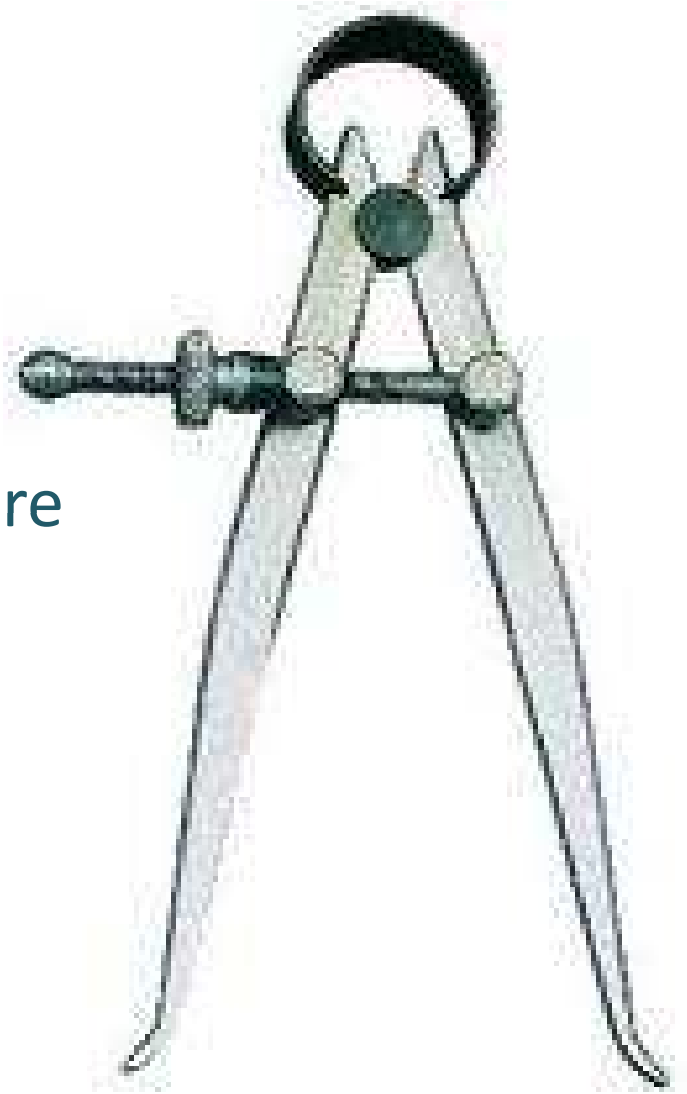
MEASURING AND MARKING

Lecture 2/7

Measuring Tools

9. Inside caliper

The inside caliper is used to measure the internal size of an object.



Measuring Tools

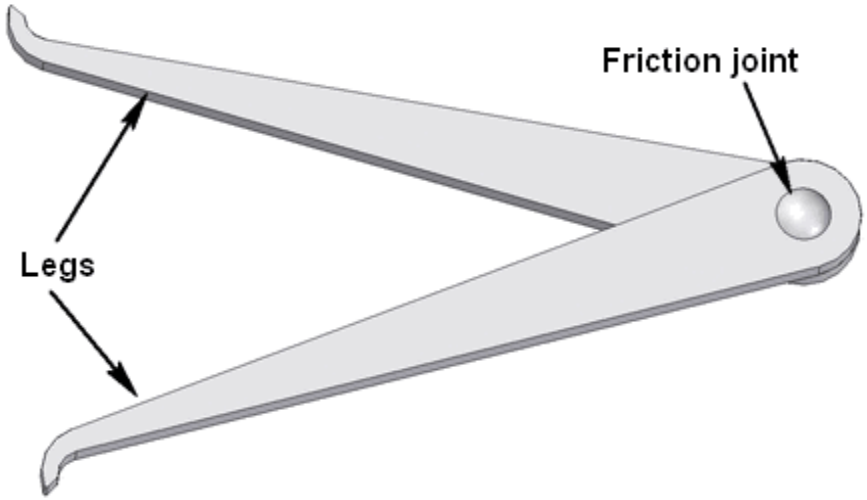
Use of Inside caliper

The Inside caliper requires manual adjustment prior to fitting, fine setting of this caliper type is performed by tapping the caliper legs lightly on a handy surface until they will *almost* pass over the object.

Measuring Tools

Types of Inside caliper

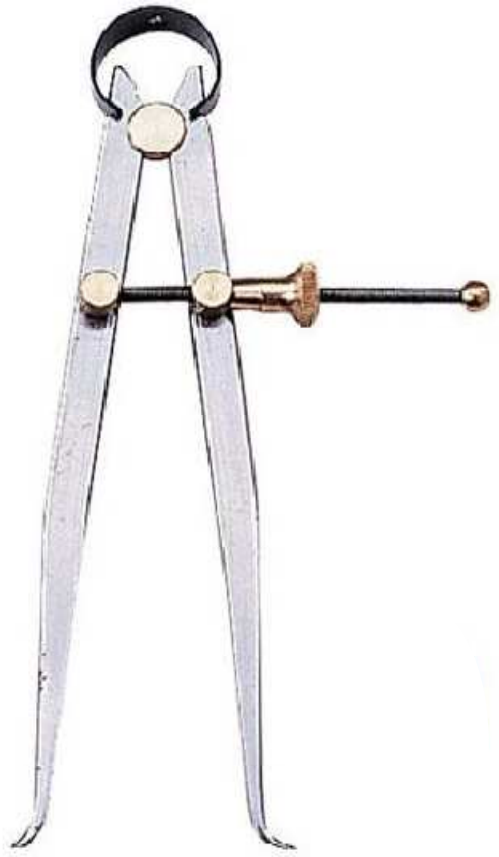
a. Firm joint inside caliper



Measuring Tools

Types of Inside caliper

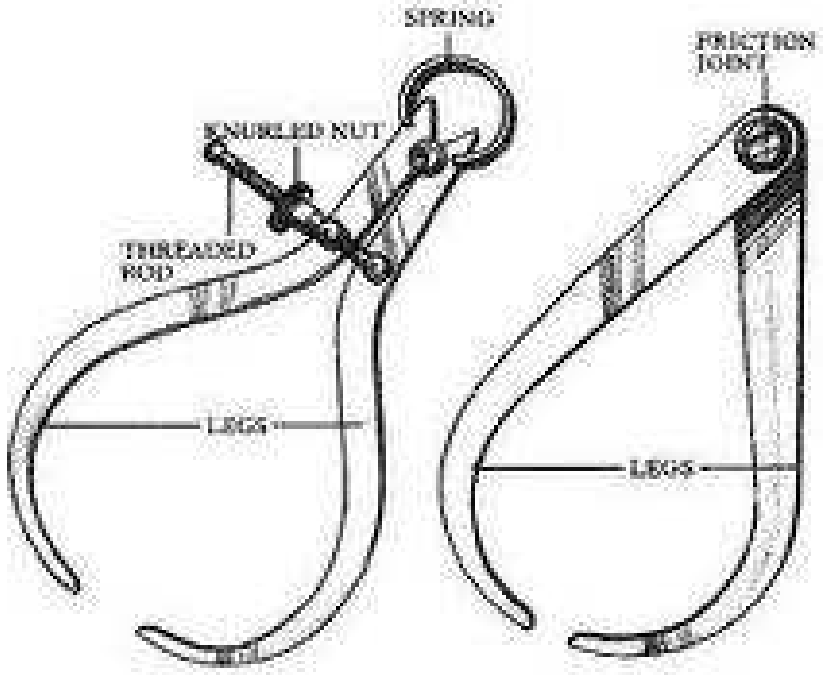
b. Adjustable Screw inside caliper



Measuring Tools

10. Outside caliper

Outside calipers are used to measure the external size of an object.



Measuring Tools

Use of outside caliper

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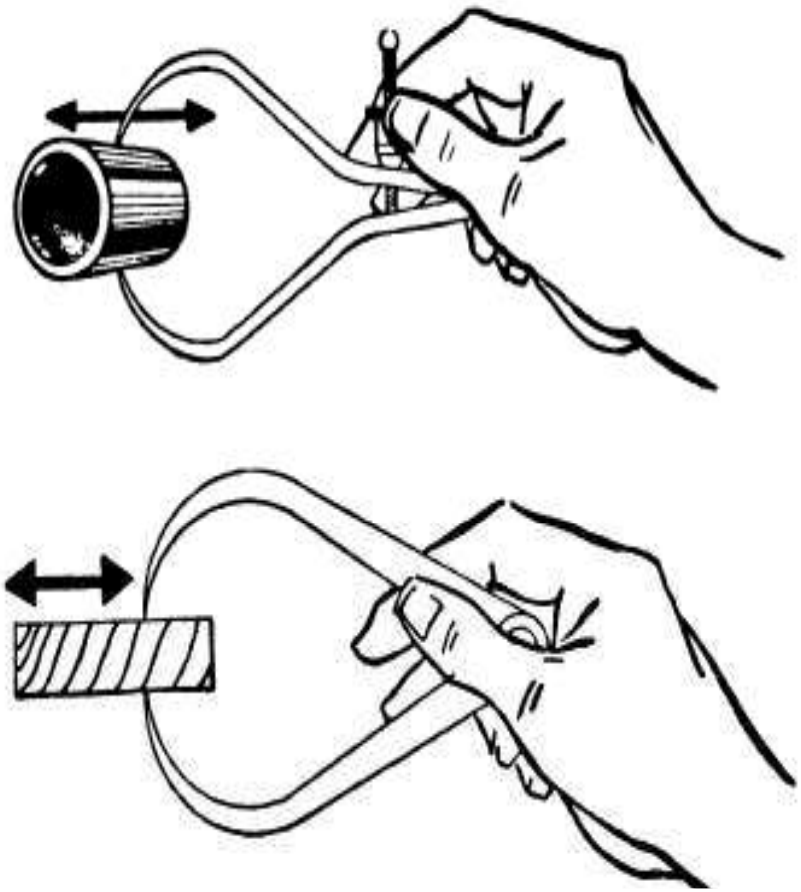

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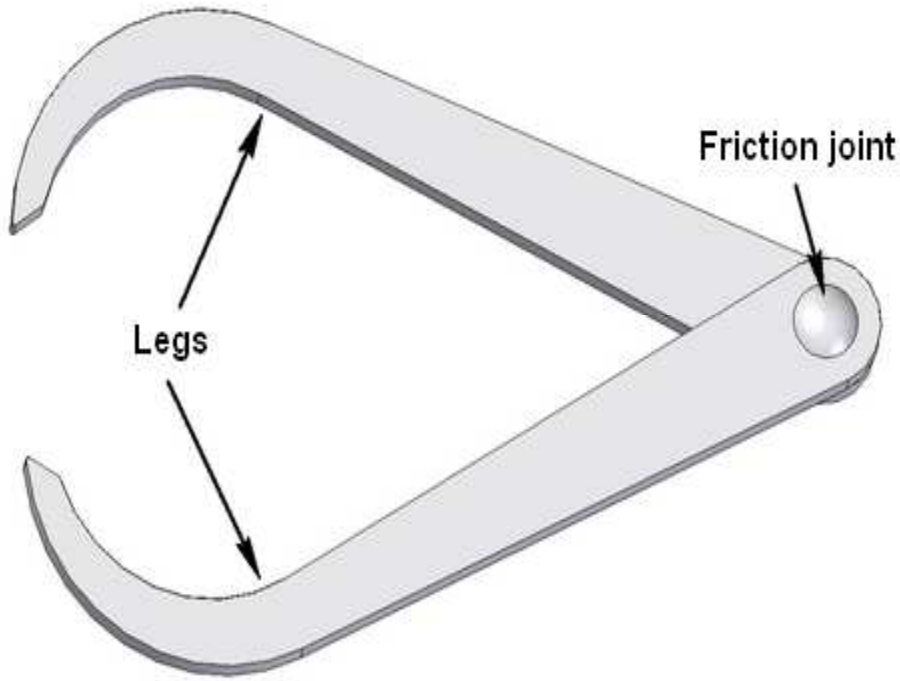
Measuring Tools

Types of outside caliper

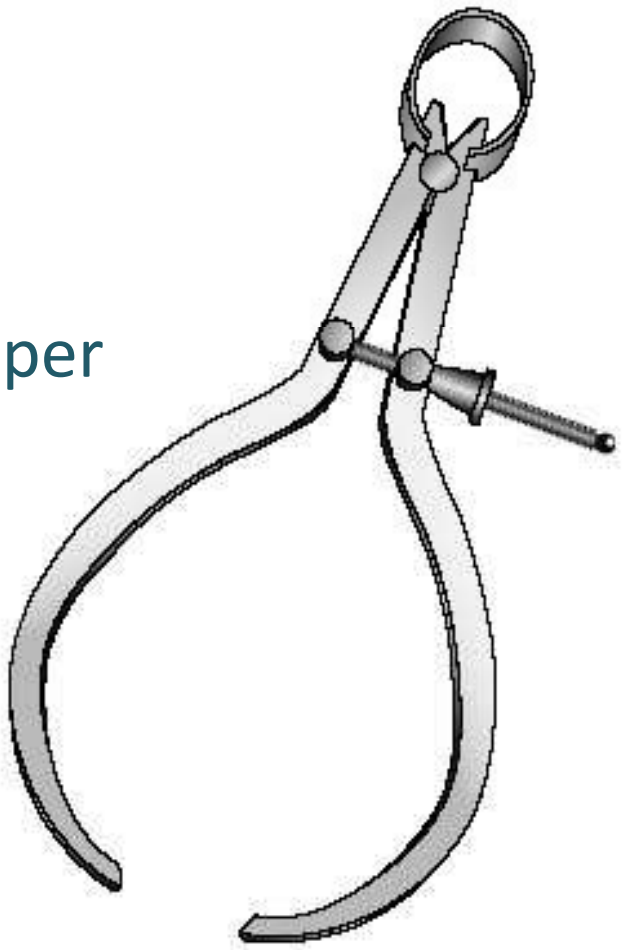
a. Firm joint outside caliper



Measuring Tools

Types of outside caliper

b. Adjustable Screw outside caliper



Measuring Tools

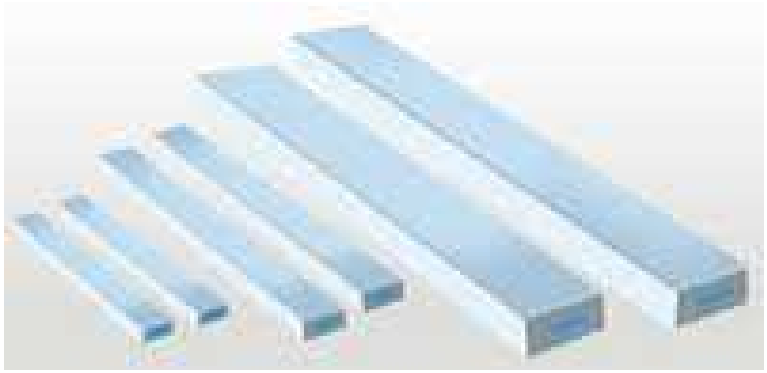
11. Surface plate/table

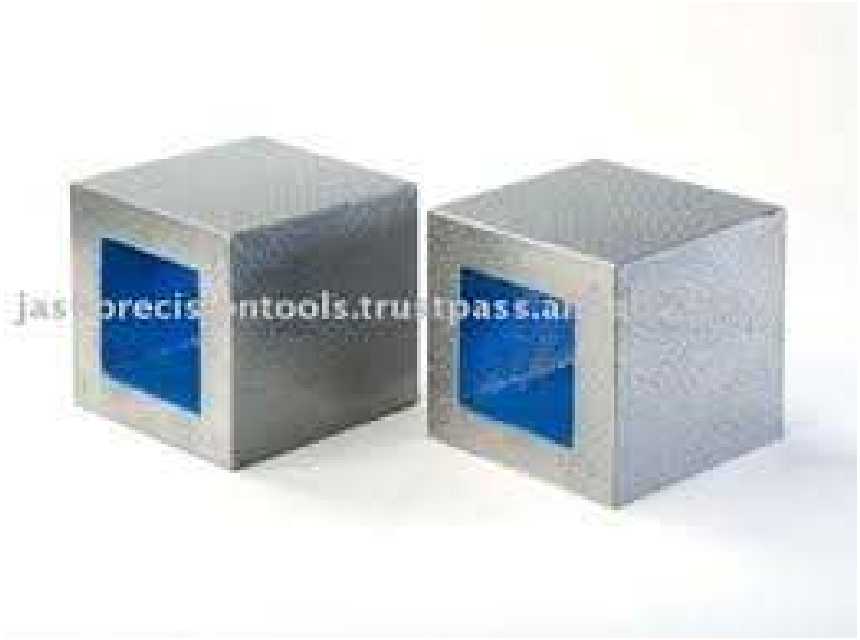
A surface plate is a solid, flat plate used as the main horizontal reference plane for precision inspection, marking out and tooling setup.

The surface plate is often used as the baseline for all measurements to the work piece.

Measuring Tools

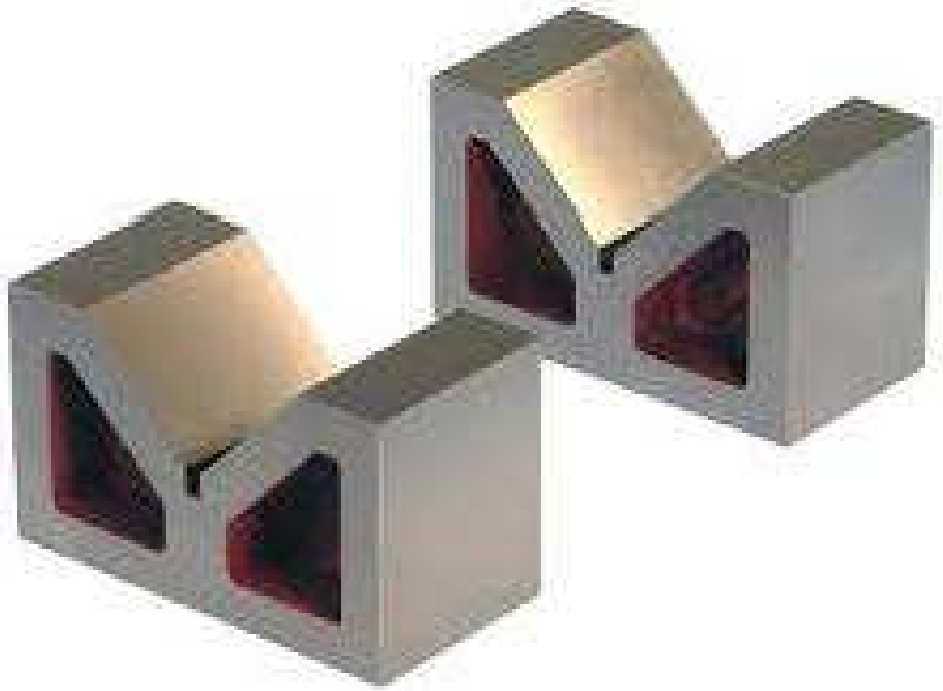
12. Parallel Blocks





Measuring Tools

13. V Block



Measuring Tools

14. Dial Indicator

Dial indicator is used for sensing or detecting small movements or size variations in a work piece.

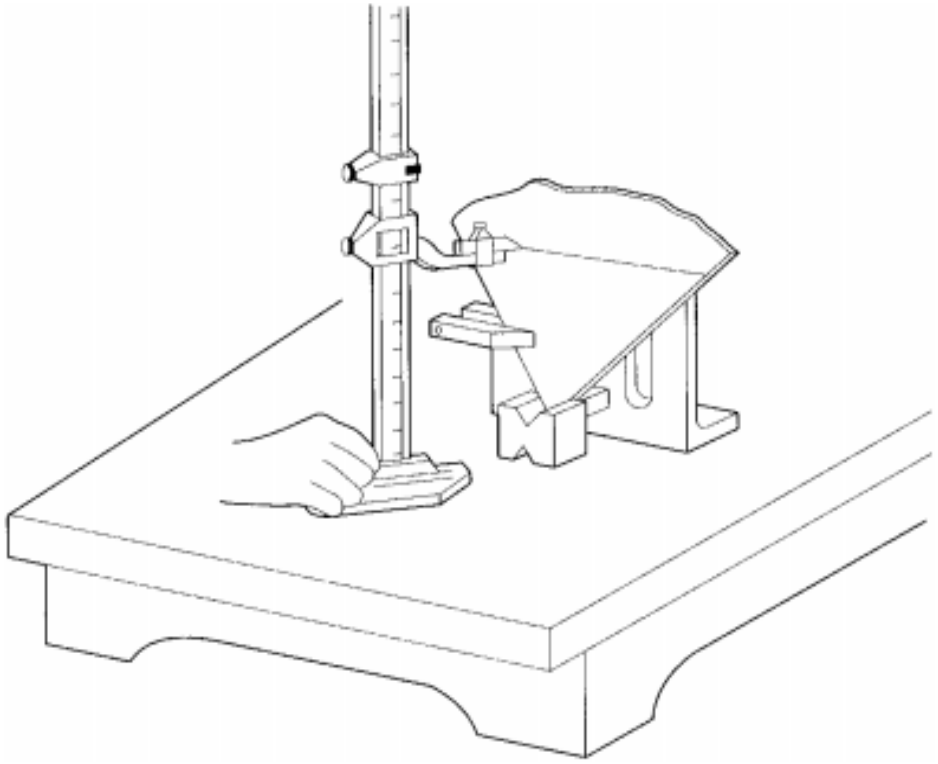
3. Measuring Tools

14. Dial Indicator

Marking Out Tools

Marking Out

Marking out is the process of transferring a design or pattern to a work piece.

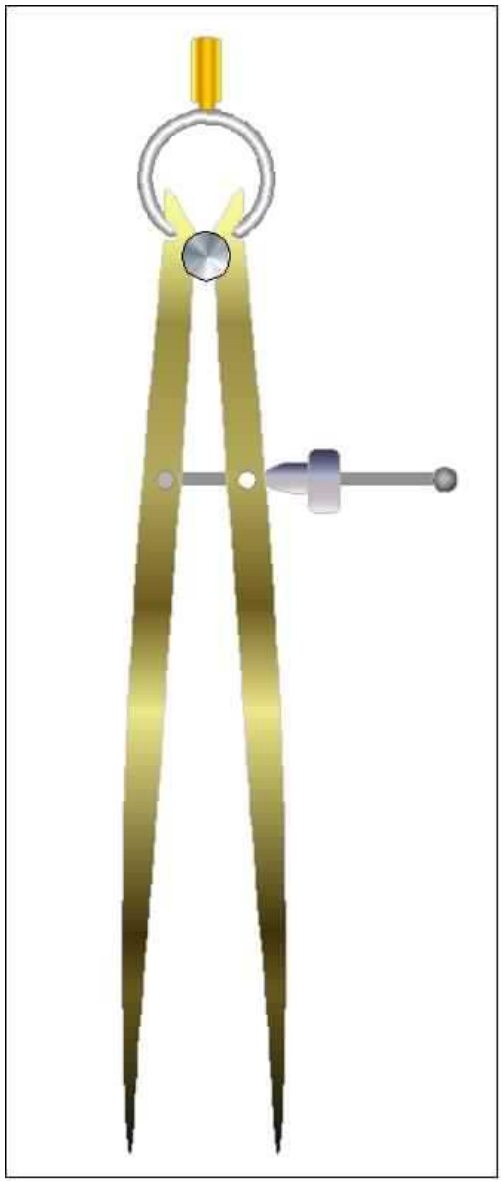


Marking Out Tools

1. Divider

Divider calipers are used in the process of marking out suitable work pieces.

The points are sharpened so that they act as scribers, one leg can then be placed in the dimple created by a center punch and the other leg pivoted so that it scribes a line on the work piece's surface, thus forming an arc or circle.



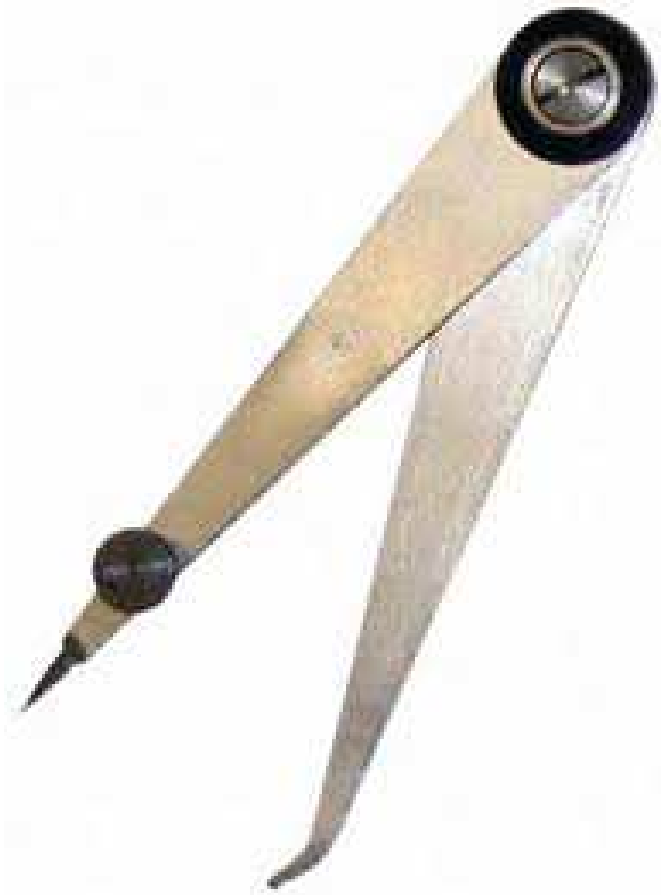
Marking Out Tools

1. Divider

Marking Out Tools

2. Odd leg Caliper

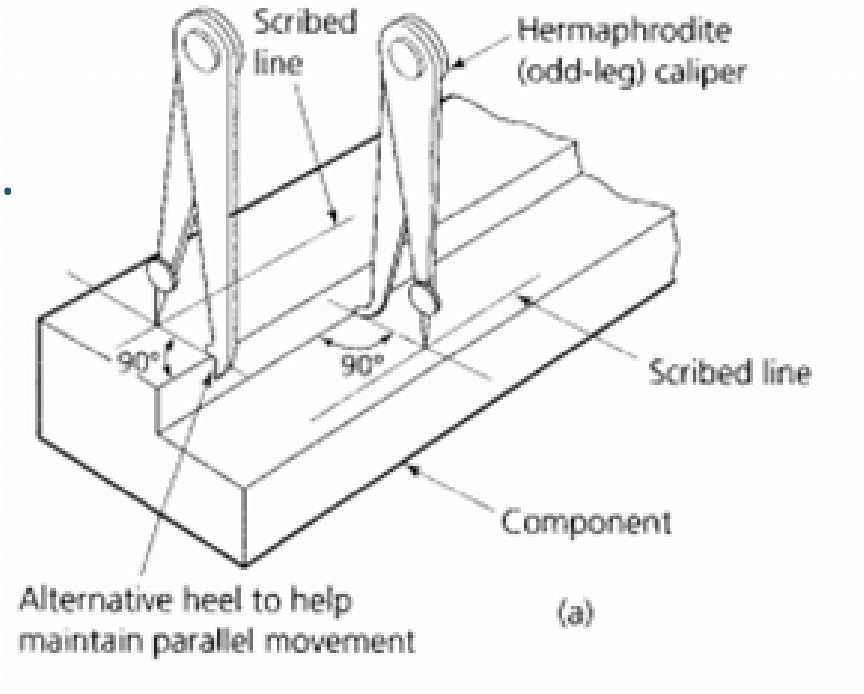
Odd leg caliper is generally used to scribe a line at a set distance from the edge of work piece.



Marking Out Tools

2. Odd leg Caliper

The bent leg is used to run along the work piece edge while the scriber makes its mark at a predetermined distance, this ensures a line parallel to the edge.



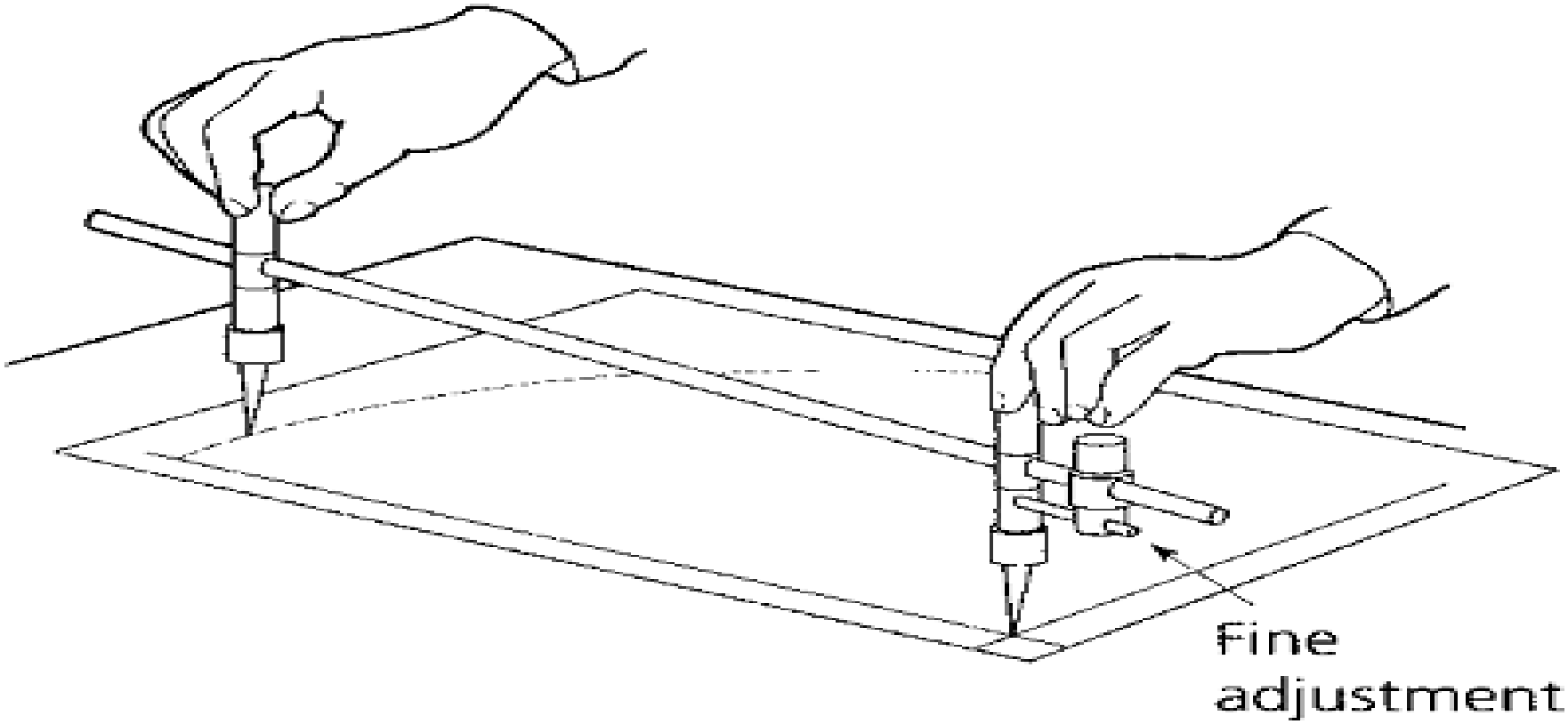
Marking Out Tools

3. Trammel

Trammels are used for marking purpose where we can not use divider.

Marking Out Tools

3. Trammel



Marking Out Tools

4. Centre punch

A center punch is used to mark the center of a point.

Marking Out Tools

4. Centre punch

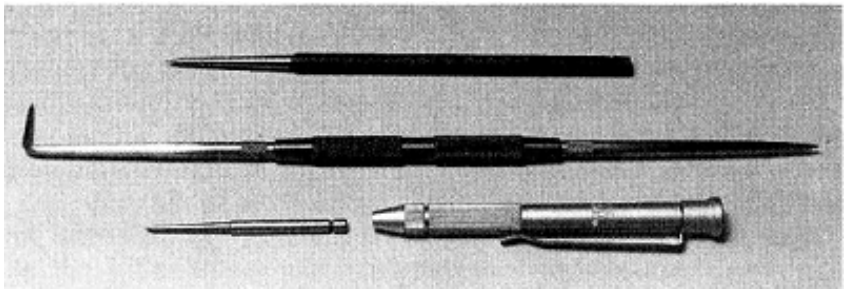
It is usually used to mark the center of a hole when drilling holes. A center punch forms a large enough dimple to "guide" the tip of the drill bit.

Marking Out Tools

5. Scriber dot

A scriber is a hand tool used in metalworking to mark lines on work pieces, prior to machining.

The process of using a scriber is called scribing.



Marking Out Tools

6. Hammer

A ball-peen also known as a blacksmith's, engineer's or machinist's hammer, is a type of peen hammer used in metalworking.

Marking Out Tools

6. Hammer

It is distinguished from a point-peen hammer or chisel-peen hammer by having a hemispherical head.

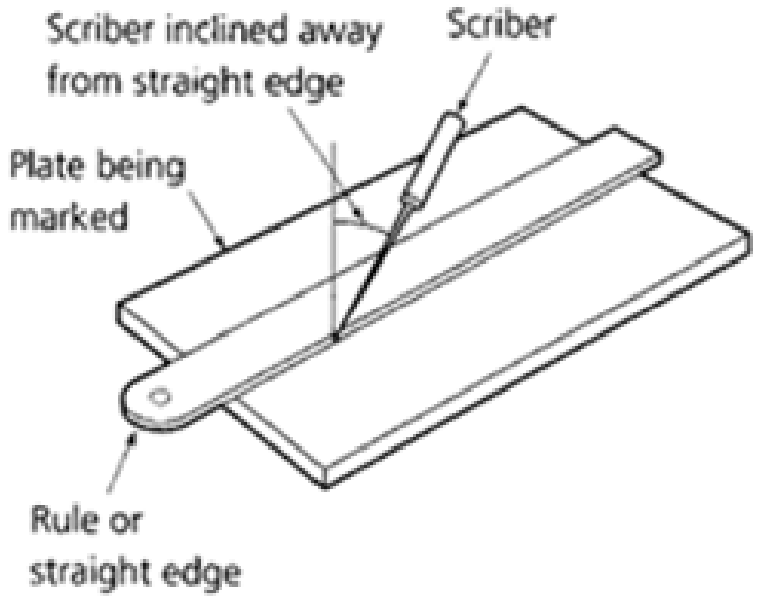
OBJECTIVE

7.3	Identify methods of marking out.

Methods of Marking out

Marking Straight Lines

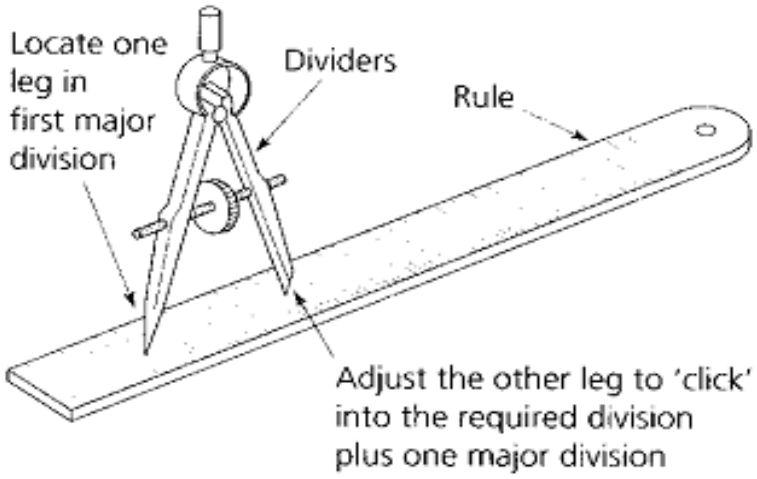
Where a straight line is required between two points, a rule can be used or, for longer distances, a straight edge.

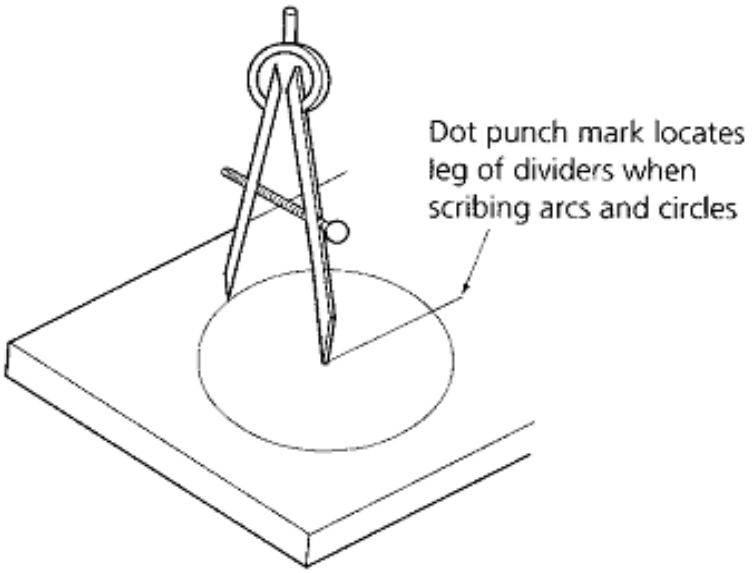


Methods of Marking out

Marking Circles and Arcs

Dividers are used to scribe circular lines and Arcs. The leg about which the dividers pivot is usually located in a fine centre dot mark. To locate the point of this leg accurately it is essential to use a sharp dot punch as shown





Methods of Marking out

Marking Circles and Arcs

Marking Hole Positions on a Pitch Circle Diameter (PCD)

Use an engineers square and odd-leg calipers to mark the position of the PCD centerlines from the datum edges.

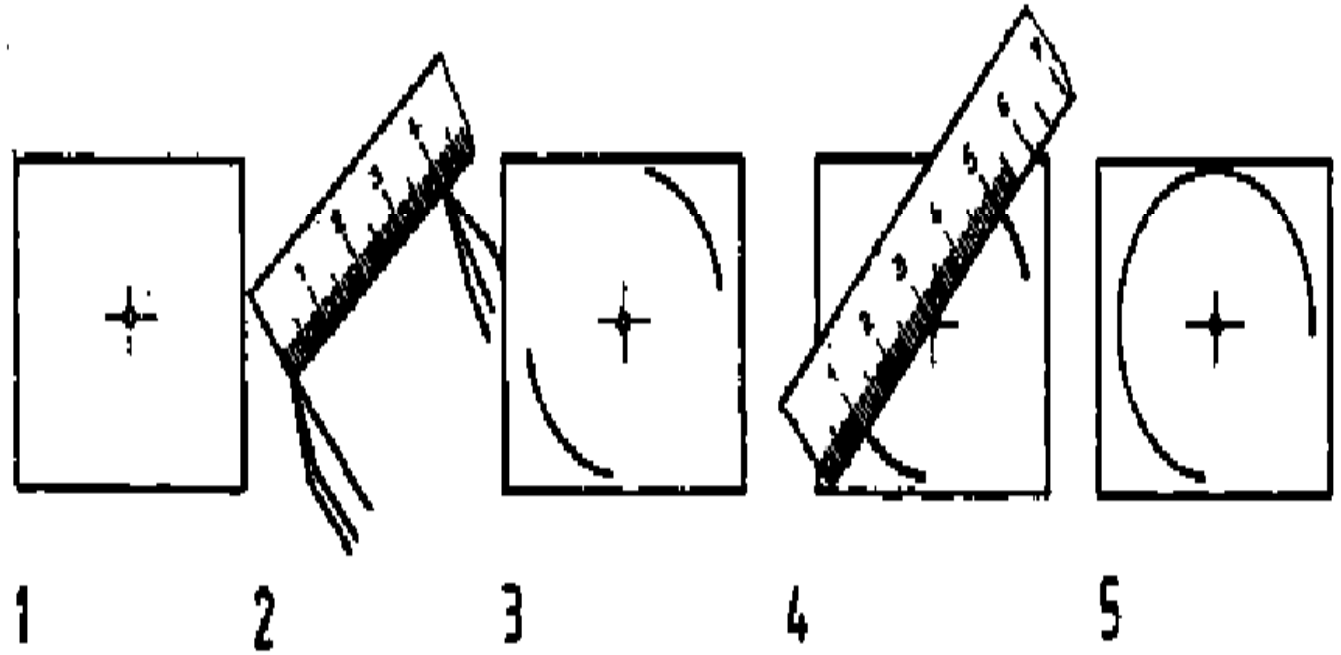
Center punch the PCD center-point and use a pair of dividers to scribe the pitch circle. Trammels are required for scribing larger PCDs.

Calculate the hole positions and use dividers to step-out and scribe the positions around the PCD.

Recheck the scribed positions. If OK, center punch the location of each hole ready for drilling.

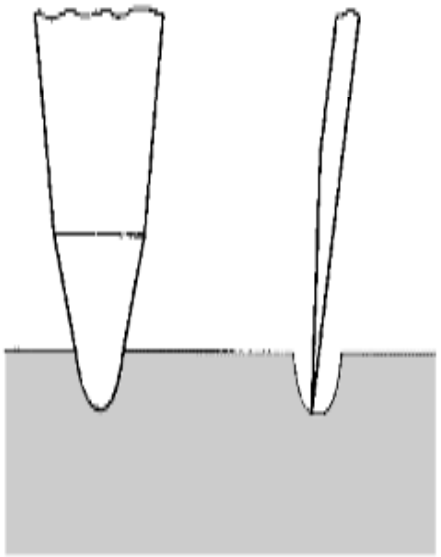
Methods of Marking out

Marking Circles and Arcs

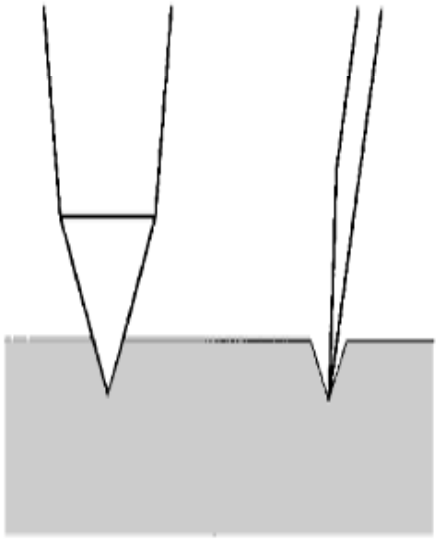


Methods of Marking out

Marking Circles and Arcs



Blunt punch – point of dividers not properly located

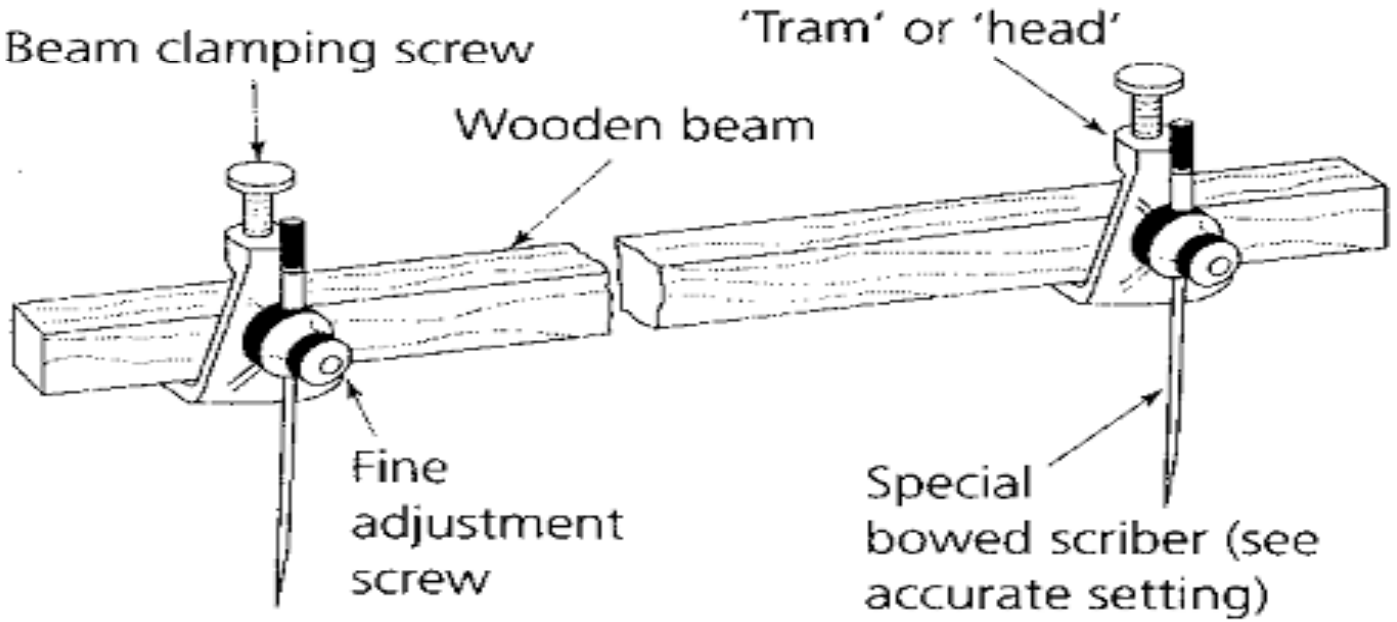


Sharp punch – locates point of punch accurately

Methods of Marking out

Marking Large Diameter Circles

Trammel is used to draw a large diameter circle or arc.



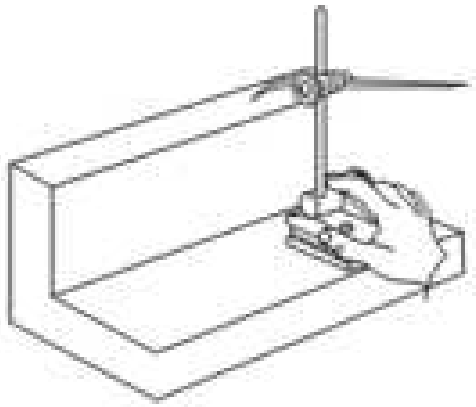
Methods of Marking out

Marking Lines Parallel Or Perpendicular The To Surface Plate

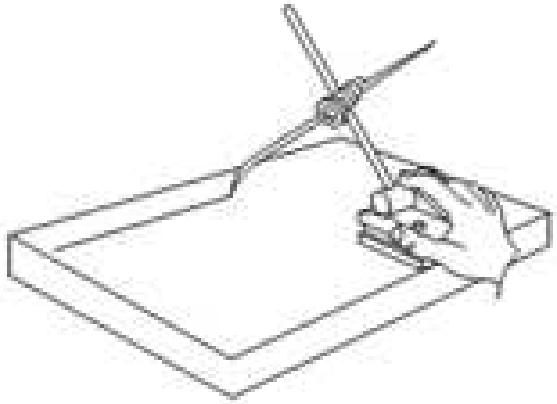
A scribing block or surface gauge is used for marking out lines parallel to a datum edge or a datum surface.

Methods of Marking out

Marking Lines Parallel Or Perpendicular The To Surface Plate



Checking a surface for parallelism



Using the setting pins to scribe parallel to an edge

Methods of Marking out

Marking parallel lines on angled sections

Place the curved leg of the caliper on the edge of the measuring stick at the zero mark.
Twist the caliper screw until the pointed caliper leg reaches the desired measurement. This measurement will equal the distance of the scribed line to the edge of the item marked.

- Place the curved leg of the caliper at the edge of the item to be marked. Set the pointed leg of the caliper on the item's surface.

Methods of Marking out

Marking parallel lines along shafts or pipes

OBJECTIVE

7.4	Identify datum and describe methods of marking out from them.

Methods of Marking Using Datum

Identify datum

Datum

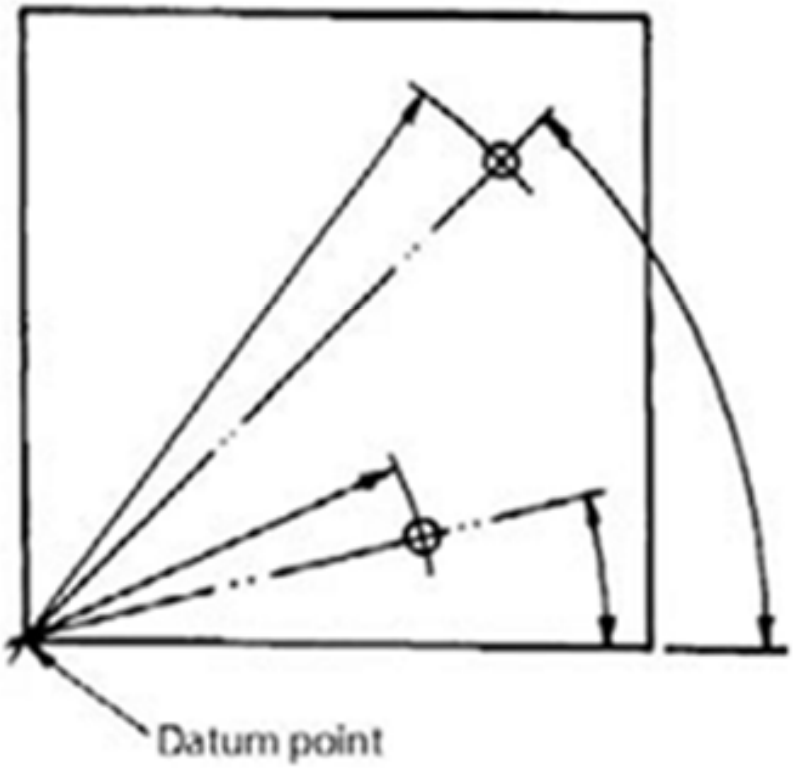
The term datum can be described as a point, line or edge, depending on the shape of the work piece from which measurements are taken. The function of a datum is to establish a reference position from which all dimensions are taken and hence all measurements are made.

Methods of Marking Using Datum

Types of datum

- **Point datum**

This is a single point from which dimensions can be taken when measuring and marking out. For example, the centre point of a pitch circle.

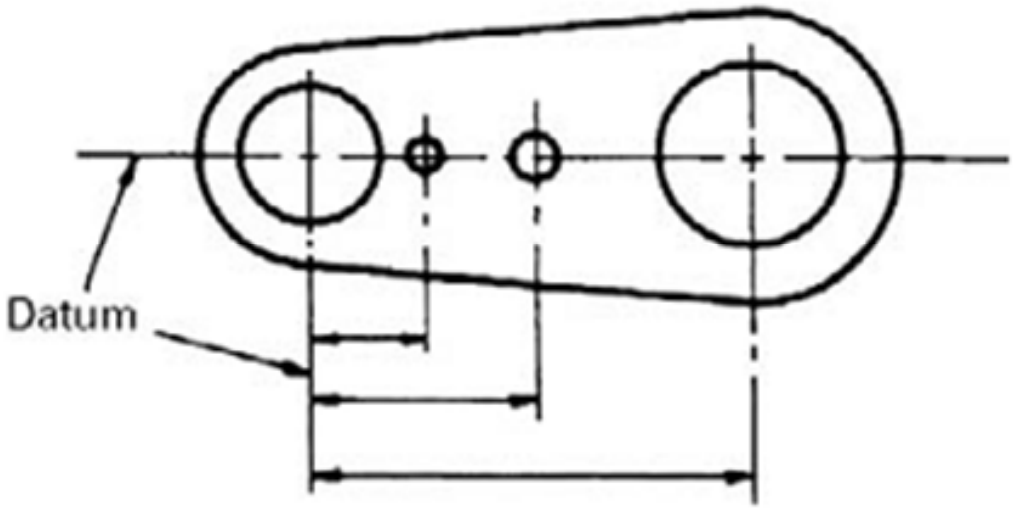


Methods of Marking Using Datum

Types of datum

- **Line datum**

This is a single line from which or along which dimensions are taken when measuring and marking out. It is frequently the centre line of a symmetrical component.



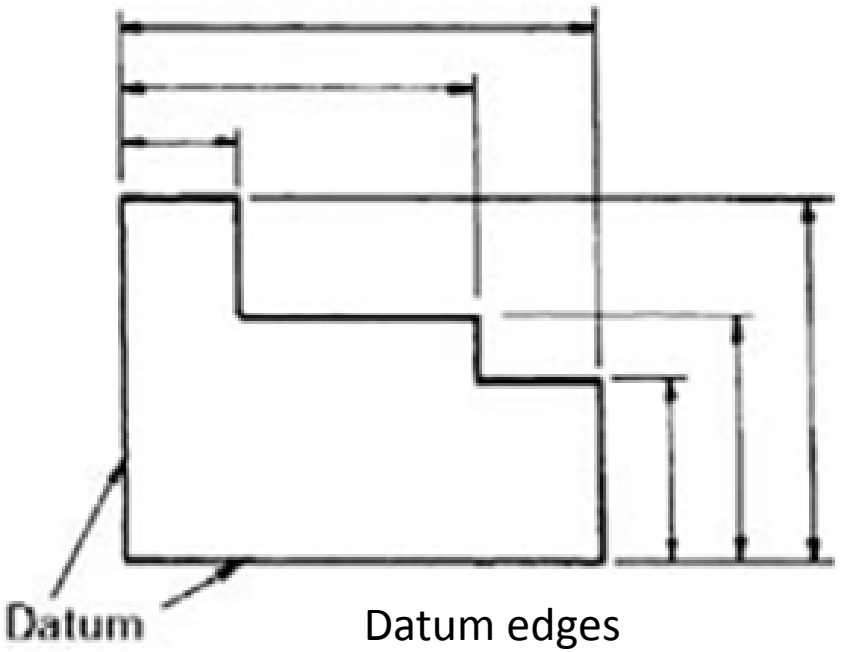
Datum centre lines

Methods of Marking Using Datum

Types of datum

- **Edge datum**

This is also known as a service edge. It is a physical surface from which dimensions can be taken. These two edges ensure that the distances marked out from them are also at right angles to each other.



Datum edges

Methods of Marking Using Datum

Types of datum

- **Surface datum**

this can be the working surface of a surface plate or a marking-out table. It provides a common datum to support the work and the measuring and marking-out equipment.

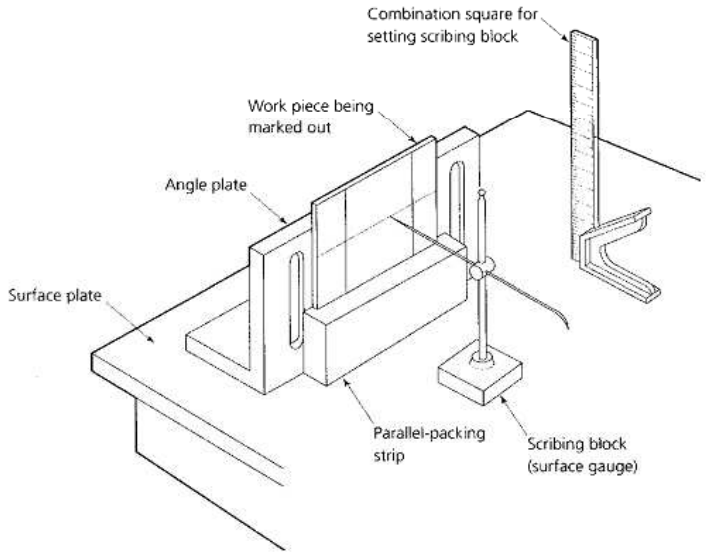


Figure 7.22 *Marking out from a datum surface – the surface plate provides the datum surface; all measurements are made from this surface; all lines scribed by the scribing block will be parallel to this surface*

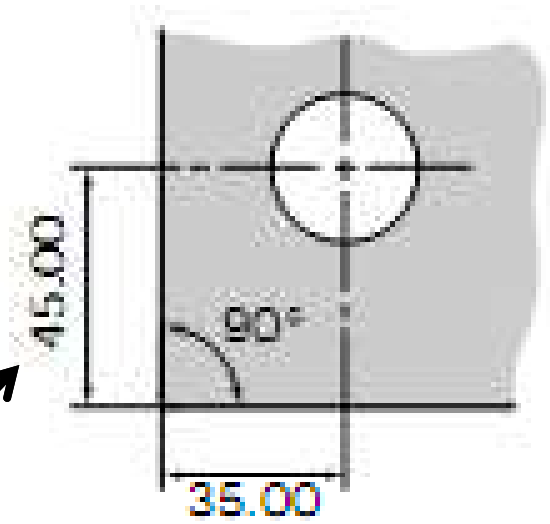
Methods of Marking Using Datum

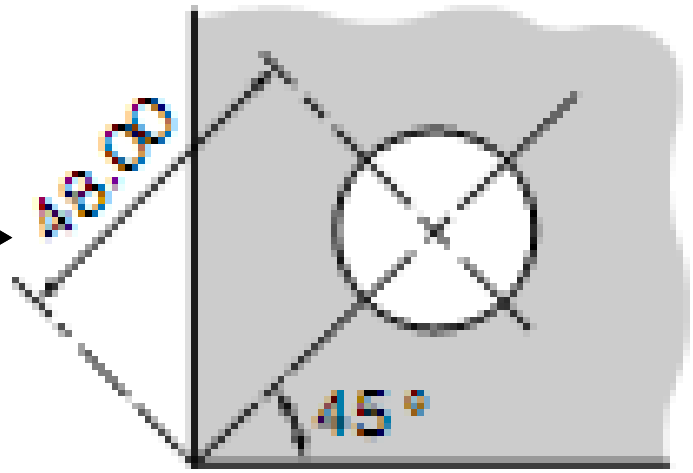
Types of datum

- **Co-ordinates systems**

The distance from a datum to some feature such as the centre of a hole is called an ordinate. There are two co-ordinates systems used in common:

1. Rectangular co-ordinates
2. Polar co-ordinates



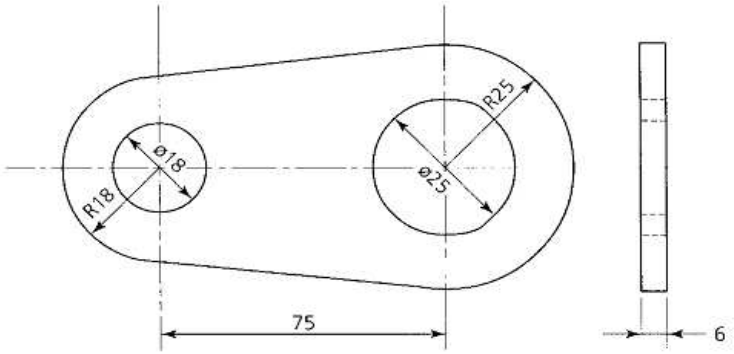


Methods of Marking Using Datum

Datum

- **Uses of datum in Marking out**

Figure shows a simple link involving straight lines, arcs, and circles. It is symmetrical about its centre line. There are several ways of marking out this component. For the moment a centre line datum will be used.

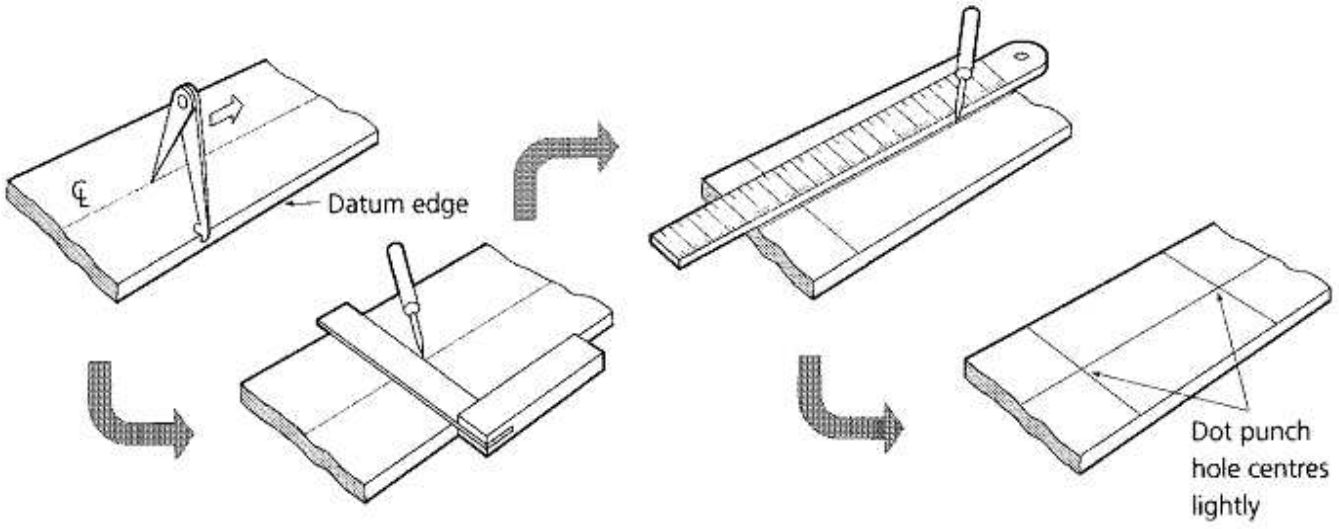


dimensions in millimetres

Methods of Marking Using Datum

- **Use of a single edge datum**

It assumes that the metal blank from which we are going to make the link has at least one straight edge.

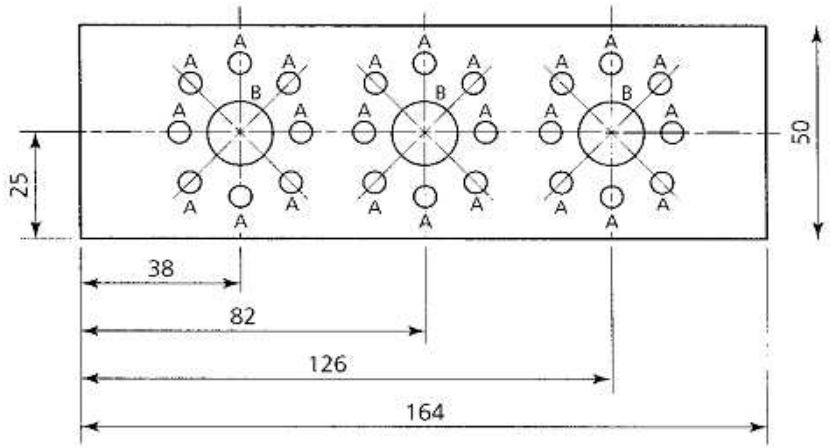


Marking out from a datum edge

Methods of Marking Using Datum

- **Use of a point datum**

a component that has been drawn using rectangular co-ordinates and absolute dimensioning for the hole centers. Each hole centre then becomes a point datum for the clusters of small holes.

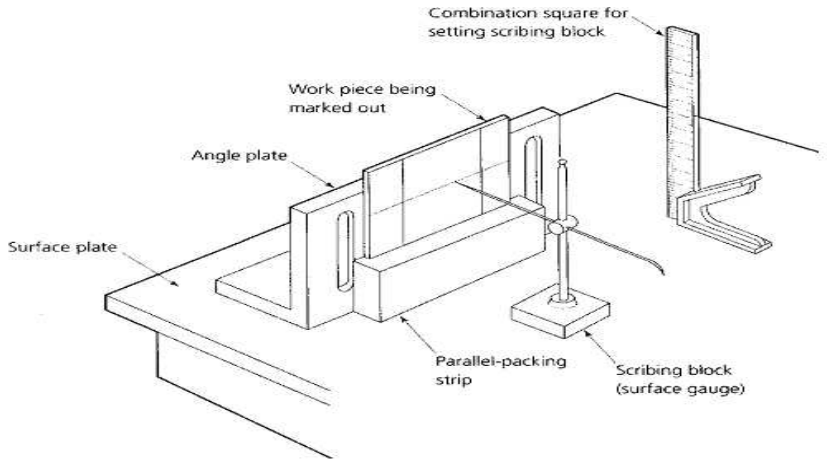


Holes A	Drill ø5 on 32 PCD equi-spaced
Holes B	Ream ø15

Methods of Marking Using Datum

- **Use of a point datum**

This time we will assume that our blank has two datum edges that are at right angles to each other; they are mutually perpendicular.



Marking out from a datum surface – the surface plate provides the datum surface; all measurements are made from this surface; all lines scribed by the scribing block will be parallel to this surface

Methods of Marking Using Datum

- **Use of a point datum**

Brush a thin layer of marking blue onto the surface of the metal bar to highlight the lines.

Use odd-leg calipers to find and scribe the centerline along the bar using one edge as the datum.

Use a rule, scriber and square to mark the hole positions along the centerline working from the datum at one end of the bar.

Use a rule to re-check the marked position.
Center punch the location of each hole ready for drilling.

Marking Hole Positions Along a Centerline

OBJECTIVE

7.10	Identify and explain the main classes of fit.

Classes of fit

- **What is Fit**

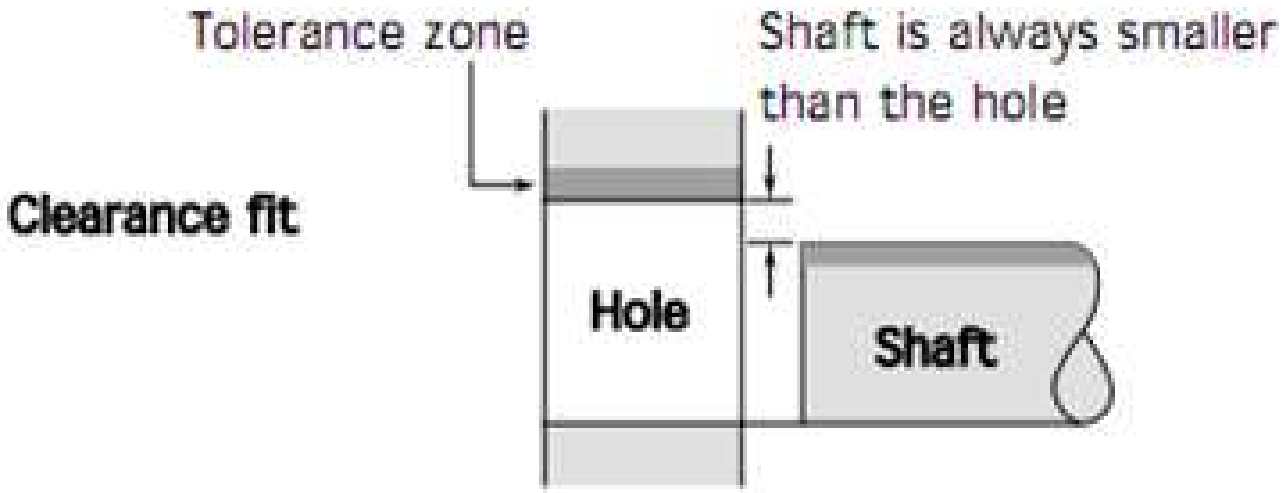
There are three classes of fit

A. Clearance fit
B. Transition fit
C. Interference fit

Classes of fit

- **A. Clearance fit**

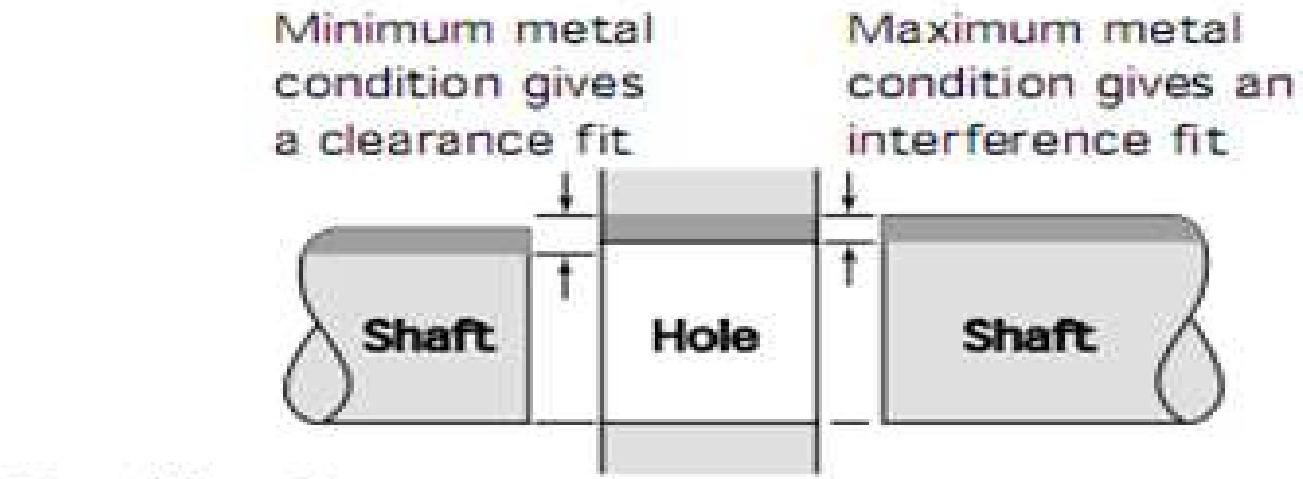
In a clearance fit the shaft is always slightly smaller than the hole.



Classes of fit

B. Transition fit

A transition fit occurs when the tolerances are so arranged that under maximum metal conditions (largest shaft: smallest hole).

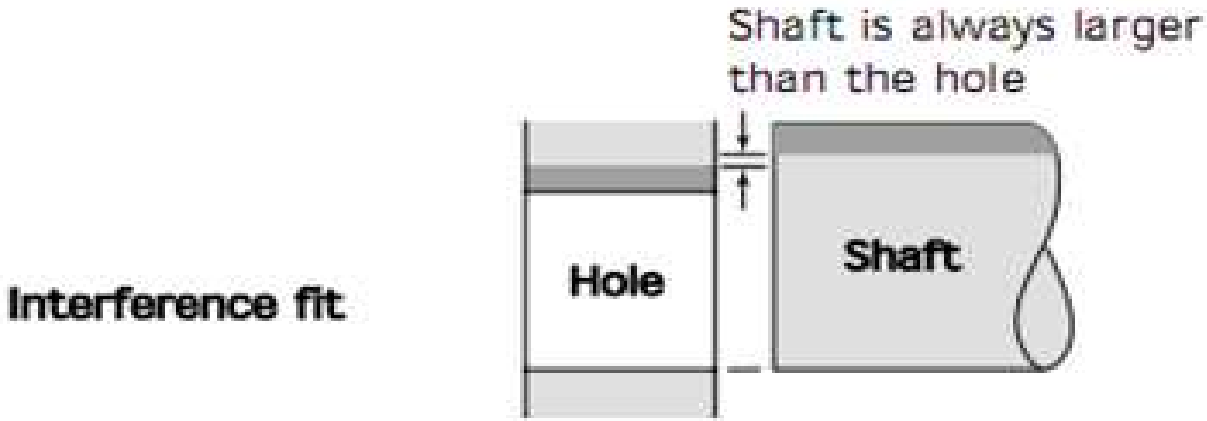


Transition fit

Classes of fit

C. Interference fit

In an interference fit the shaft is always slightly larger than the hole. In a clearance fit the shaft is always slightly smaller than the hole.



OBJECTIVE

7.6	Identify and describe the operation of tools and equipment for angular marking out and measurement.

Angular marking out and measurement

Measuring angles

Angles are measured in degrees and fractions of a degree. One degree of arc is 1/360 of a complete circle. One degree of arc can be subdivided into minutes and seconds. With the introduction of calculators and computers, decimal fractions of a degree are also used. However, 1 minute of arc equals 0.0166666◦

Angular marking out and measurement

Vernier bevel protractor

The Vernier bevel protractor uses the principle of two scales, one moving and one fixed. The fixed scale is graduated in degrees. The moving or Vernier scale is divided into 12 equal parts.

Angular marking out and measurement

Bevel Gauge

This 3" wide hardened stainless steel 12" rule with a satin chrome finish is etched on one side with inch measurements in 1/16" increments on one edge with center finding markings on the other edge. The other side of the rule shows angles from 0° to 50° in clear, distinct 1/4 degree increments.

Angular marking out and measurement

Combination Set

A combination set is a tool used for multiple purposes in metalworking.

Angular marking out and measurement

Combination set

It is useful for a wide variety of layout and setup tasks. When used correctly, a fairly high degree of precision can be achieved.

Angular marking out and measurement

Marking-out Using a Combination Set

A scriber and a combination set protractor can be used for marking-out virtually any angle from a datum face.

A scriber and a combination try-square can be used for marking-out at 90° and 45° to a datum face.

A combination set center-finder is used for scribing intersecting lines to establish the center of a round bar or circular shape.

Angular marking out and measurement

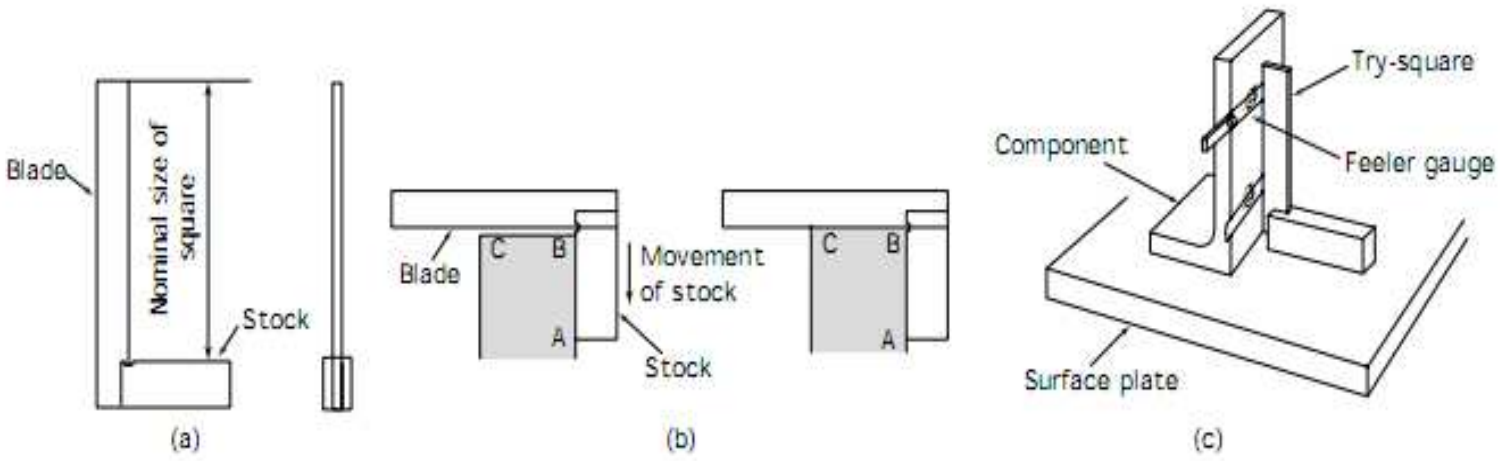
Try square

A tri square is tool used for marking and measuring a piece of wood.

Angular marking out and measurement

Try square

Primary use is measuring the accuracy of a right angle.



OBJECTIVE

7.5	Describe how to avoid faults and minimize inaccuracies when marking out

Avoiding faults/inaccuracies

use of appropriate equipment

No matter how accurately measuring equipment is made and no matter how sensitive it is, one of the most important factors affecting the accuracy of measurement is the skill of the user. The more important procedures for the correct use of measuring equipment can be summarized as follows.

Avoiding faults/inaccuracies

condition of equipment

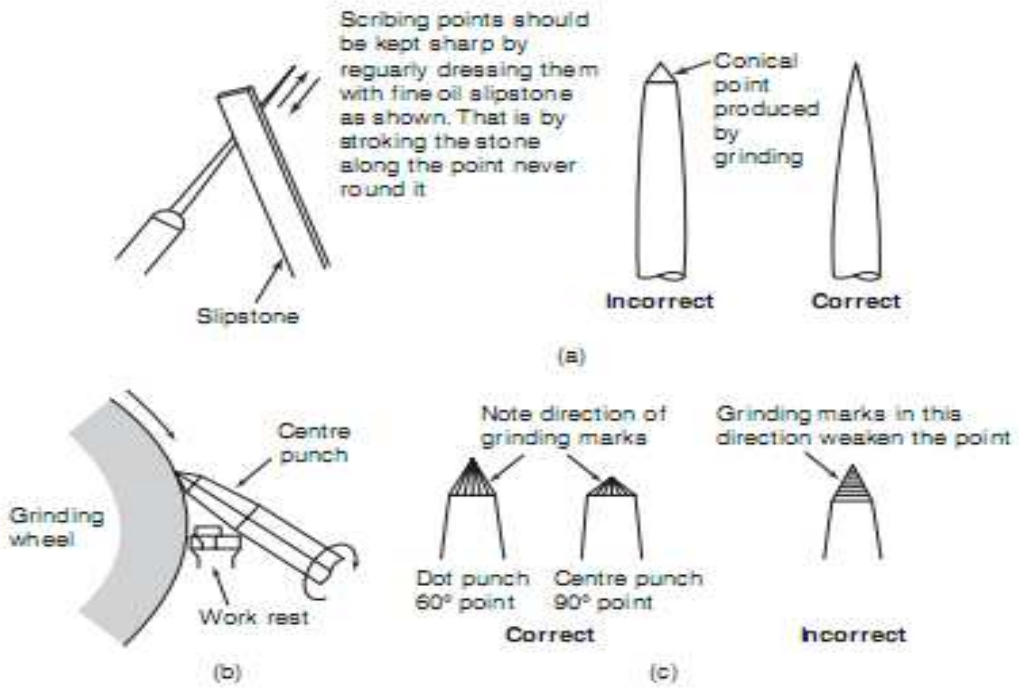
No matter how accurately measuring equipment is made and no matter how sensitive it is, one of the most important factors affecting the accuracy of measurement is the skill of the user. The more important procedures for the correct use of measuring equipment can be summarized as follows.

Avoiding faults/inaccuracies

condition of equipment

Avoiding faults/inaccuracies

condition of equipment

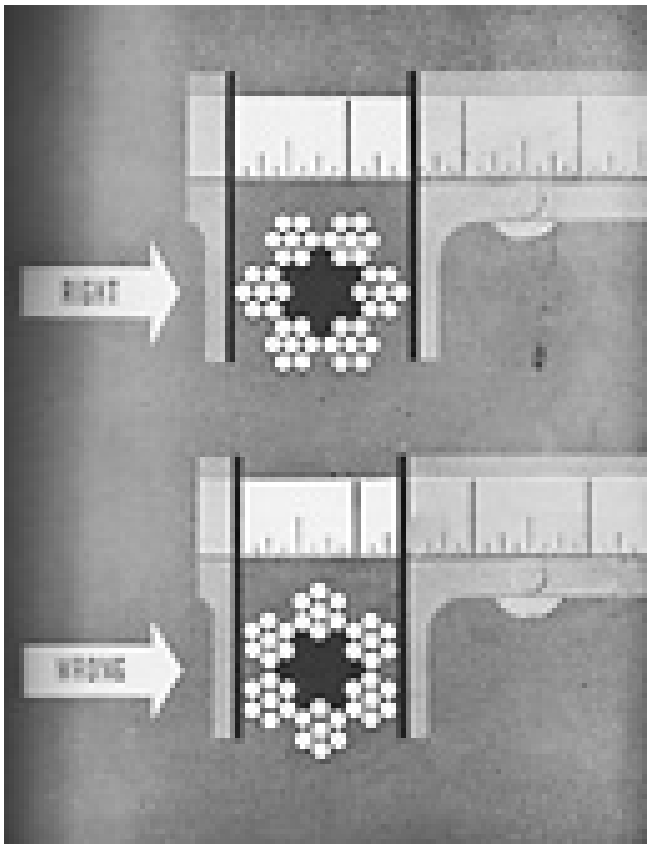


Care of marking-out equipment: (a) sharpening scriber points; (b) sharpening a centre punch. And dot punches; (c) correct and incorrect dot and centre punch point configurations

Avoiding faults/inaccuracies

correct positioning of equipment

No matter how accurately measuring equipment is made and no matter how sensitive it is, one of the most important factors affecting the accuracy of measurement is the skill of the user. The more important procedures for the correct use of measuring equipment can be summarized as follows.



OBJECTIVE

7.7	Identify and explain the use of the precision bubble level to establish horizontal and vertical planes

Precision bubble level

spirit level or bubble level

A spirit level or bubble level is an instrument designed to indicate whether a surface is horizontal (level) or vertical (plumb).

OBJECTIVE

7.8	Identify and explain the use of the plumb bob to establish vertical planes

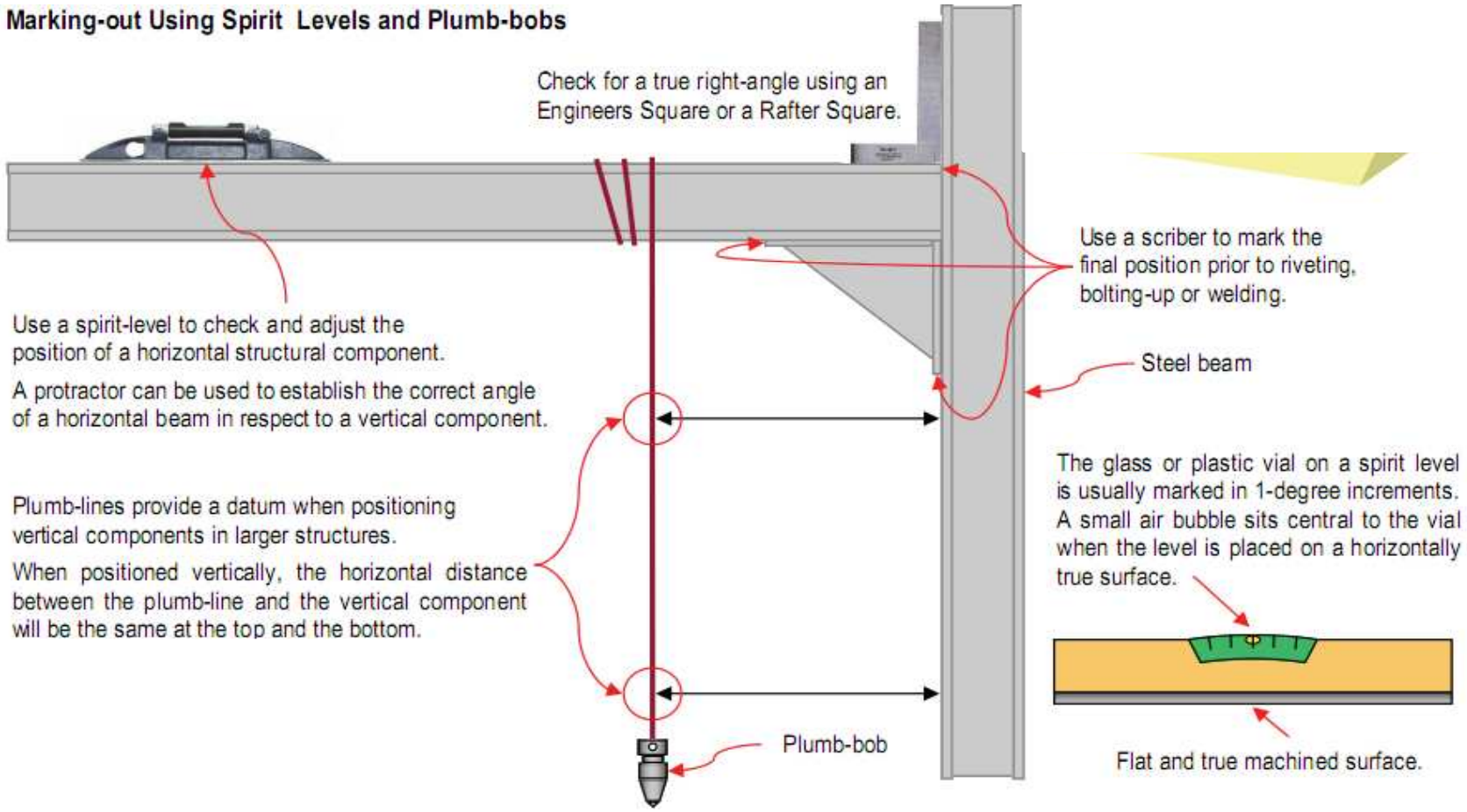
Precision Plumb bob

Plumb bob

A plumb-bob or a plummet is a weight, usually with a pointed tip on the bottom, that is suspended from a string and used as a vertical reference line, or plumb-line.

use of the precision Plumb bob

Use of the precision Plumb bob and Spirit level



OBJECTIVE

7.9	Identify template materials for given situations and describe their use.

Template materials

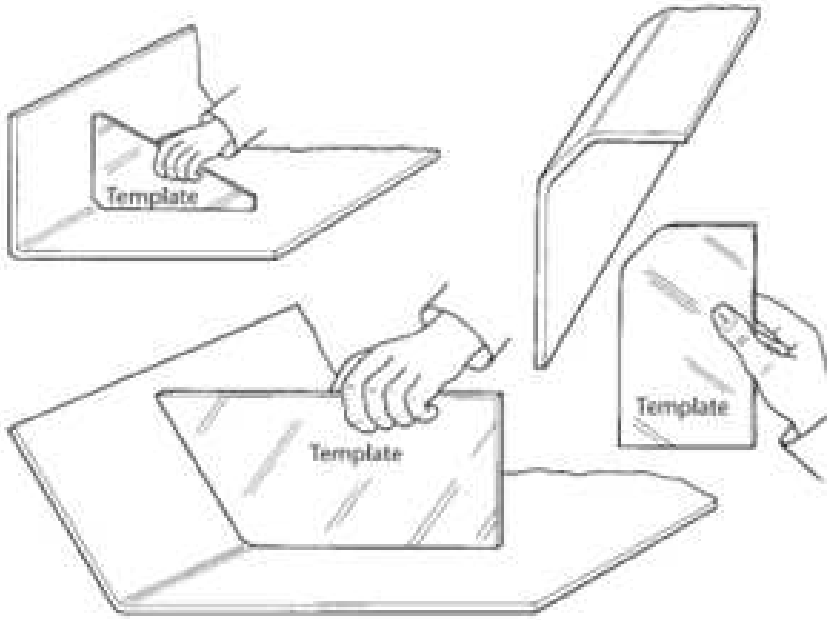
The use of templates

The use of templates simple components of a structure do not require to be set out on the template floor (lofted) but can be marked out directly from the drawings at the bench in the fabrication shop. However, even for simple jobs, templates need to be made where a number of identical components are required to ensure uniformity. Let's now consider some examples of the use of templates in greater detail.

Template materials

Templates for checking

Templates for checking are made out of metal or wood, depending upon their size and life expectancy.



(a)

It is often necessary to make simple bending templates especially if the sheet or plate material requires bending in several places to definite angles
These templates are generally made from sheet metal

Template materials

Templates for Marking out

Light gauge sheet metal and template-making paper are the materials most frequently used for making templates (patterns) for sheet metal fabrications. For many sheet metal developments it is only necessary to use part patterns which are aligned with datum lines.

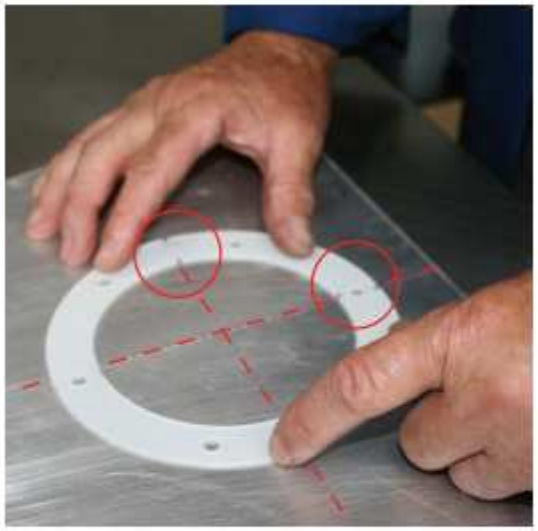
Template for Marking out

Marking Shapes and Hole Positions Using Templates

Templates are commonly made of sheet metal, plastic and wood and shaped to represent the finished article. Templates can be simple geometric shapes or detailed profiles used for fabricating complex structures.

Hole positions in the template are marked on the work-piece surface using **transfer punches**.

Use an a square, odd-leg calipers, a rule and a scriber to lay-out the template



Locate the template on the alignment marks. Clamp in place if necessary.

Use a scriber to mark-out the template profiles. Use transfer punches to mark the locations of the holes ready for drilling. Use a rule to re-check the profiles and hole positions.

Radius gauge

screw cutting centre gauge