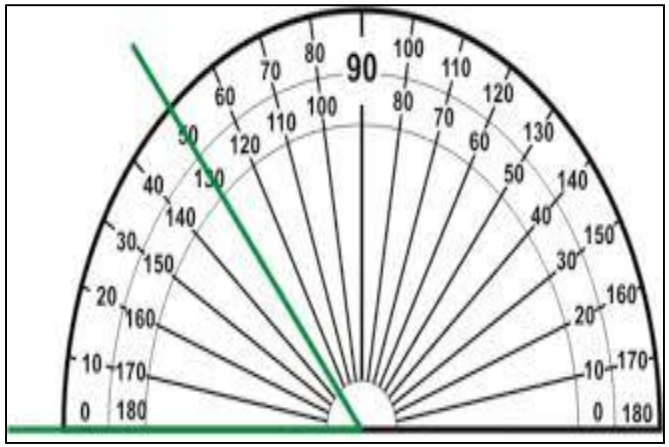
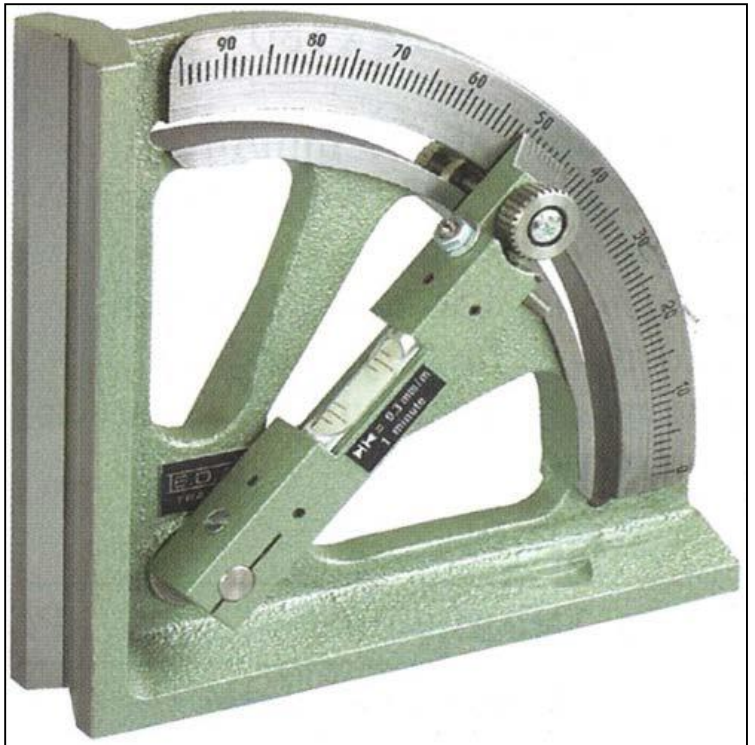
Angular Measurements





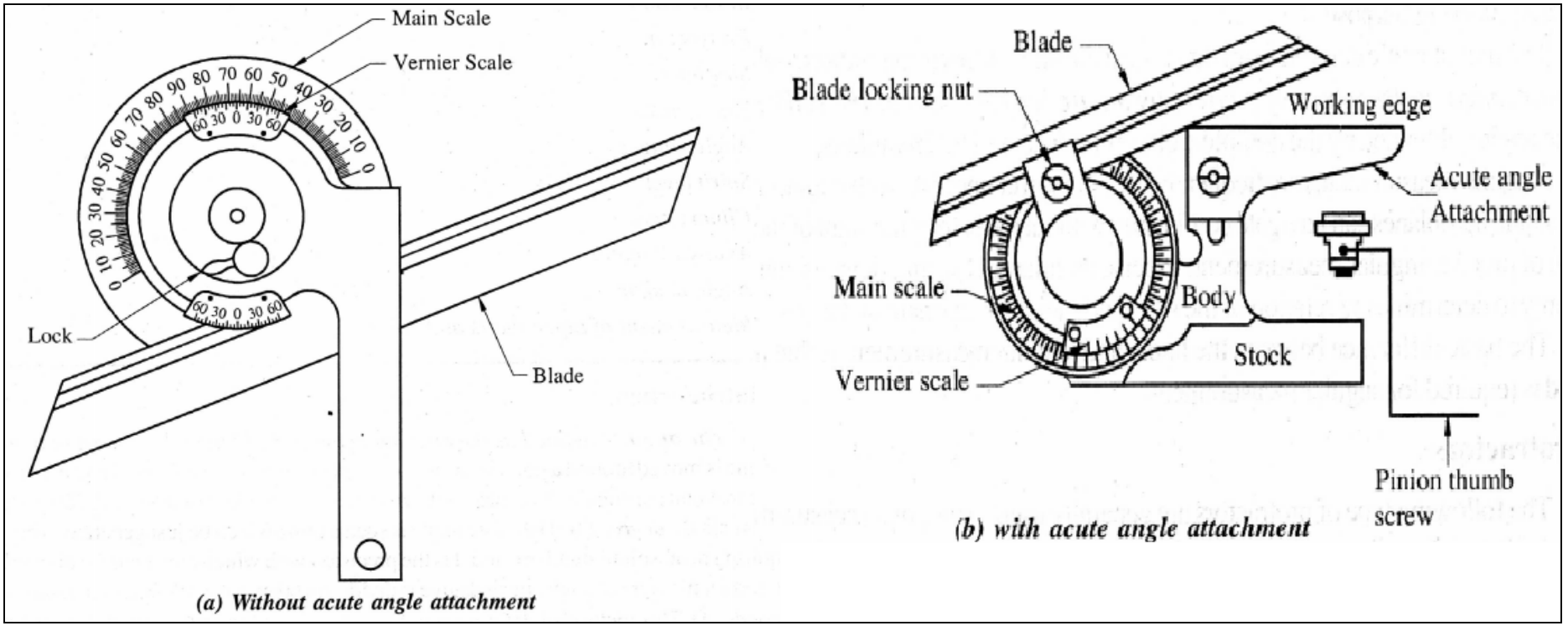
Introduction

- The angle is defined as the opening between two lines which meet at a point.
- Circle is divided into 360 parts, each part is called a degree (º).
- Each degree is divided in 60 minutes (') and each minute into 60 Seconds (“)
- Unit of angle derived from theoretical considerations is the radian, defined as the angle subtended at the centre of a circle by an are length equal to radius of circle.

Angle Measurement Instrument

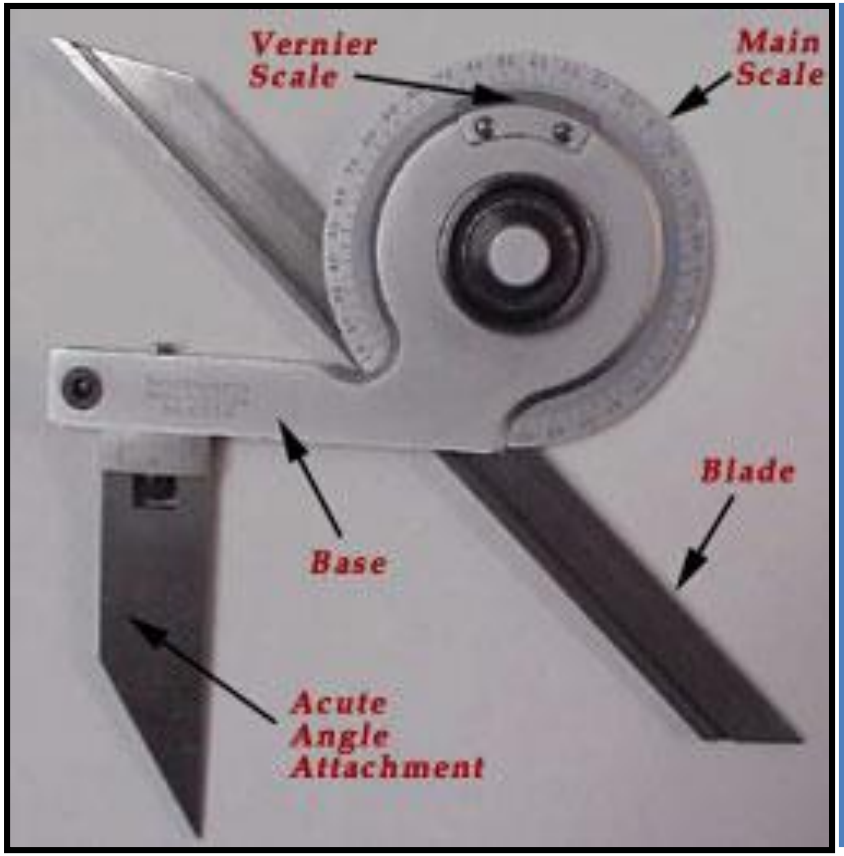
- Line Standard Angular Measuring Devices
- Protractors
- Universal Bevel Protractors
- Face Standard Angular Measuring Devices
- Sine bar
- Sine Center
- Measurement of Inclines
- Spirit Level
- Clinometer
- Angle Comparators
- Autocollimators

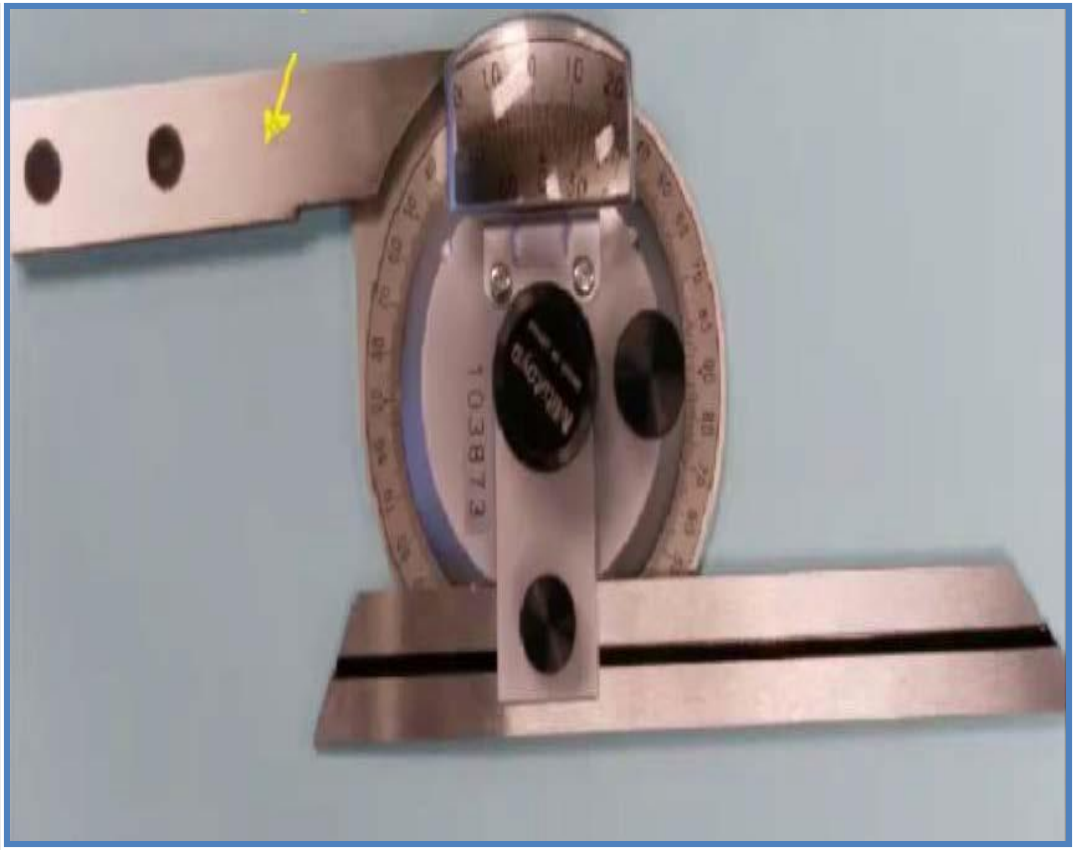
Vernier Bevel protractor



The simplest instrument for measuring the angle between two faces of component.

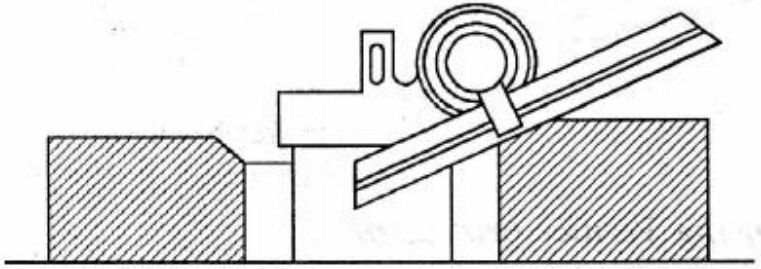
•Main scale on the protractor is divided into degrees from 0 to 90 each way.


Vernier Scale
Main Scale
Blade
Base
Acute Angle Attachment

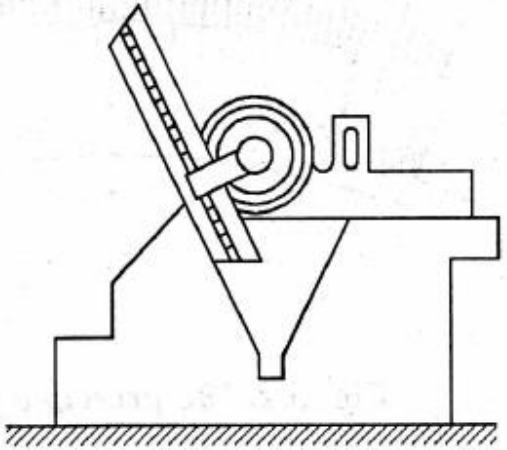


- **Applications of the vernier bevel protractor**

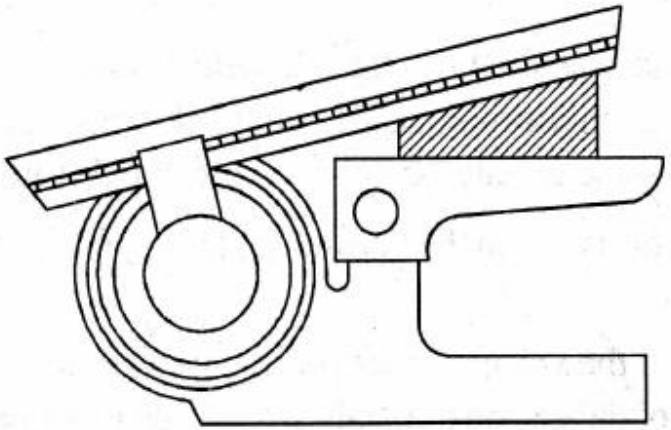
Fig 3.4 shows the various applications of vernier bevel protractors.



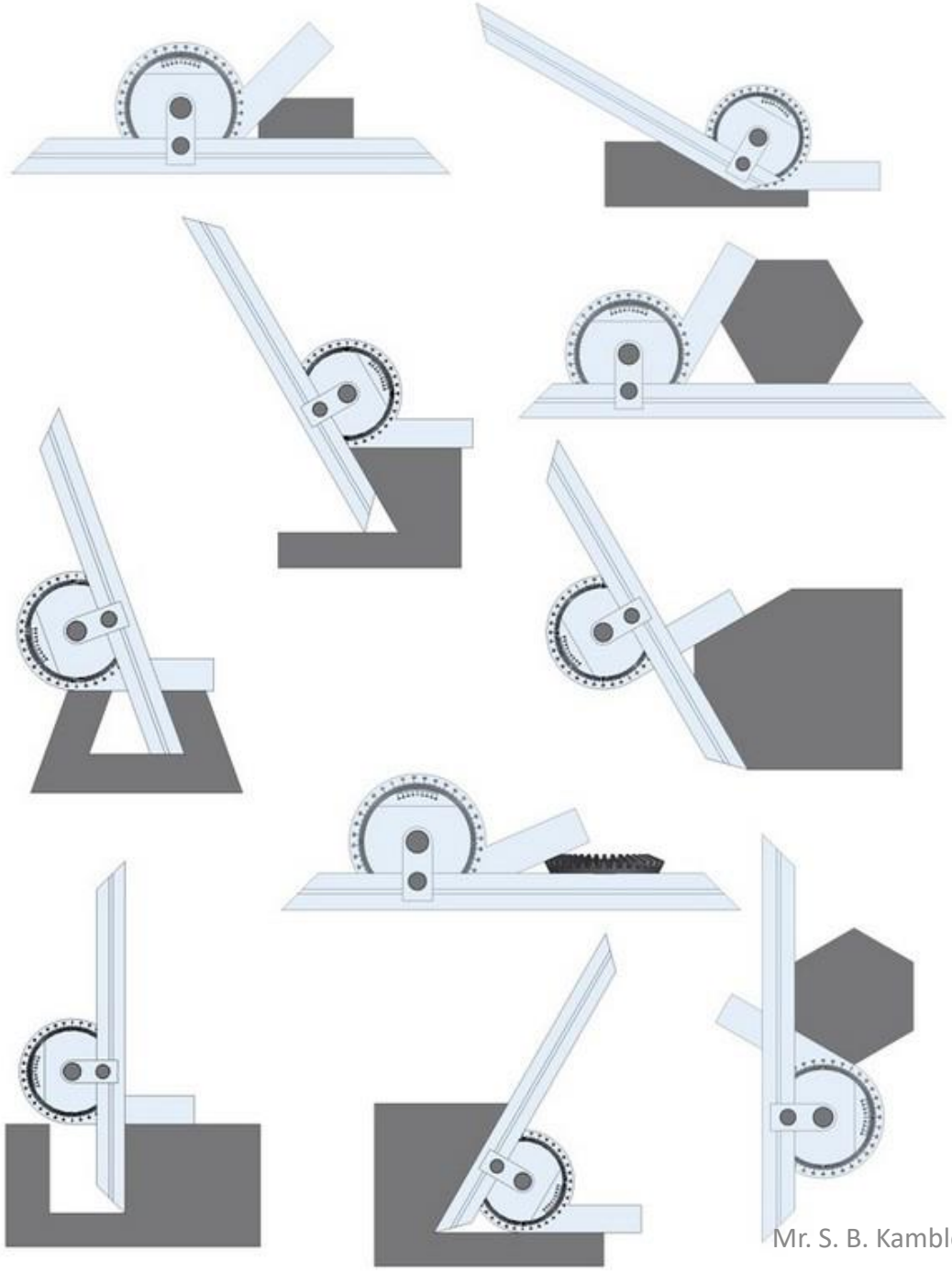
(a) Use of bevel protractor for checking inside beveled face of a ground surface

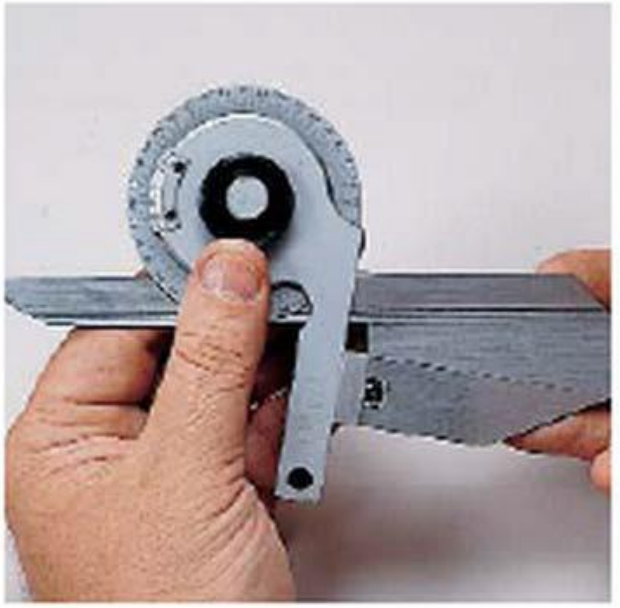


(b) Use of bevel protractor for checking 'V' block



(c) Use of bevel protractor for measuring acute angle



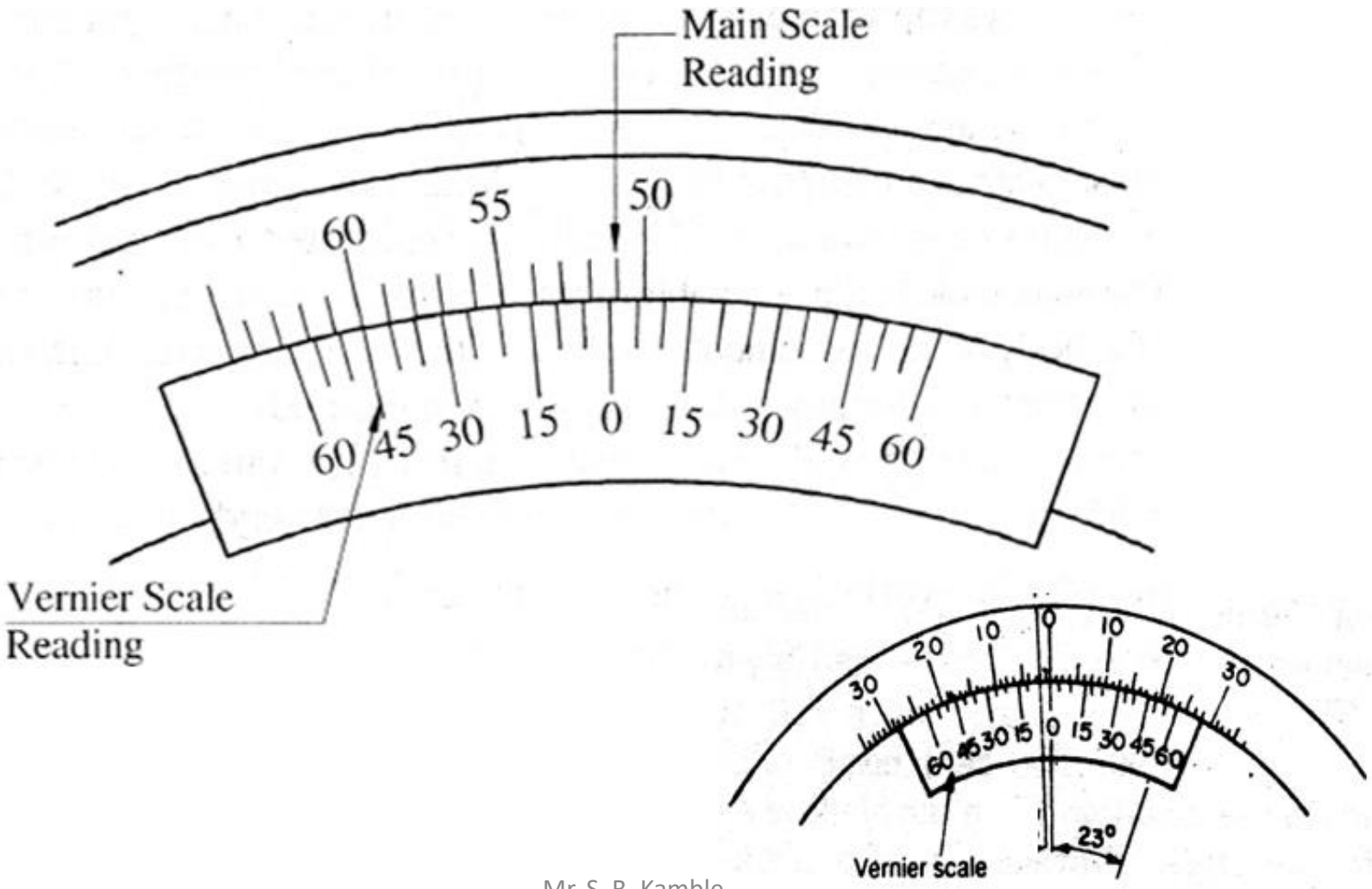


Measuring acute angle.

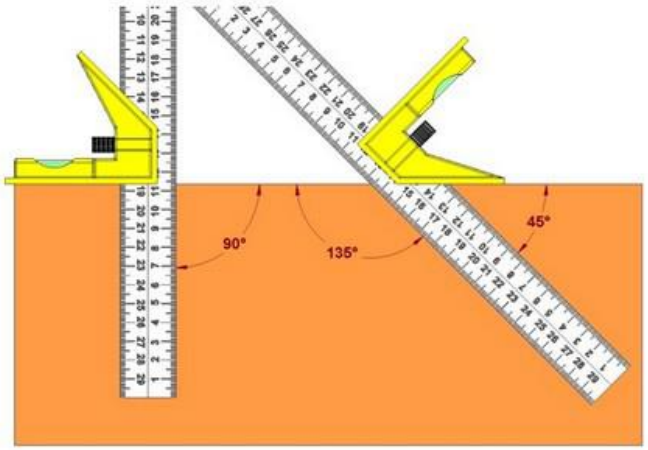
Measuring obtuse angle.

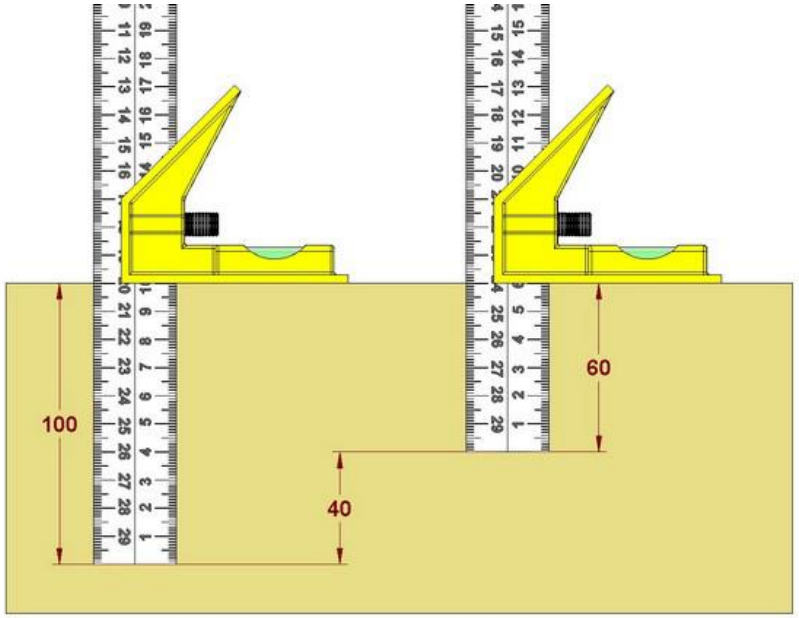
Measuring Acute Angles

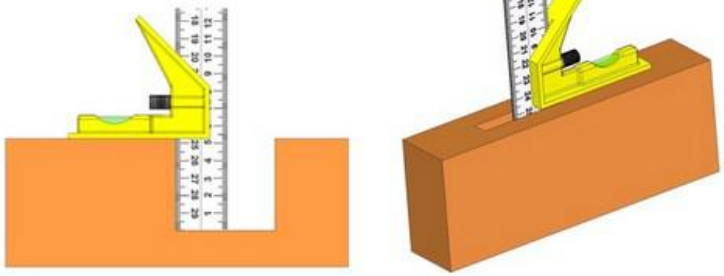
Measuring Obtuse Angles

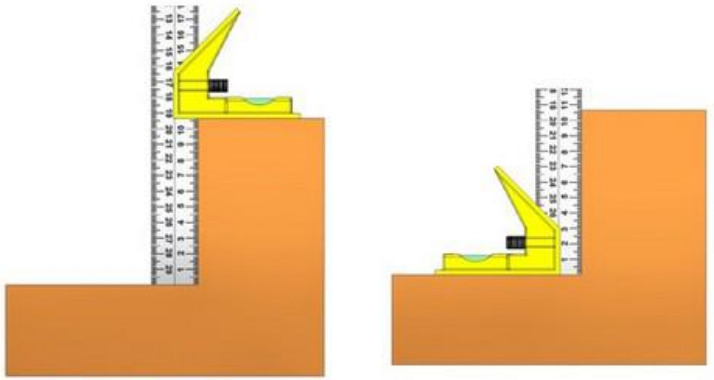

Main Scale
Reading
60
55
50
60 45 30 15 0 15 30 45 60
Vernier Scale
Reading
30
20
10
0
10
20
30
60 45 30 15 0 15 30 45 60
23°
Vernier scale

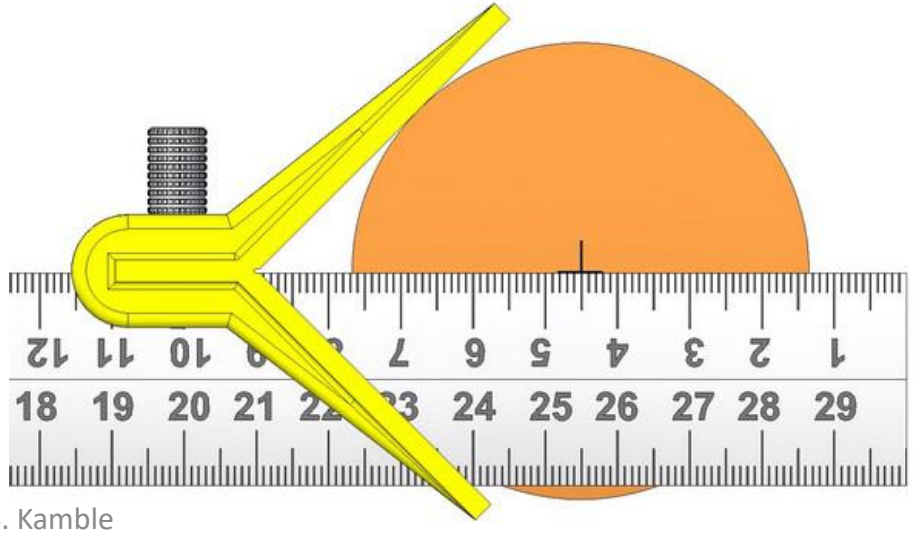
Combination Set



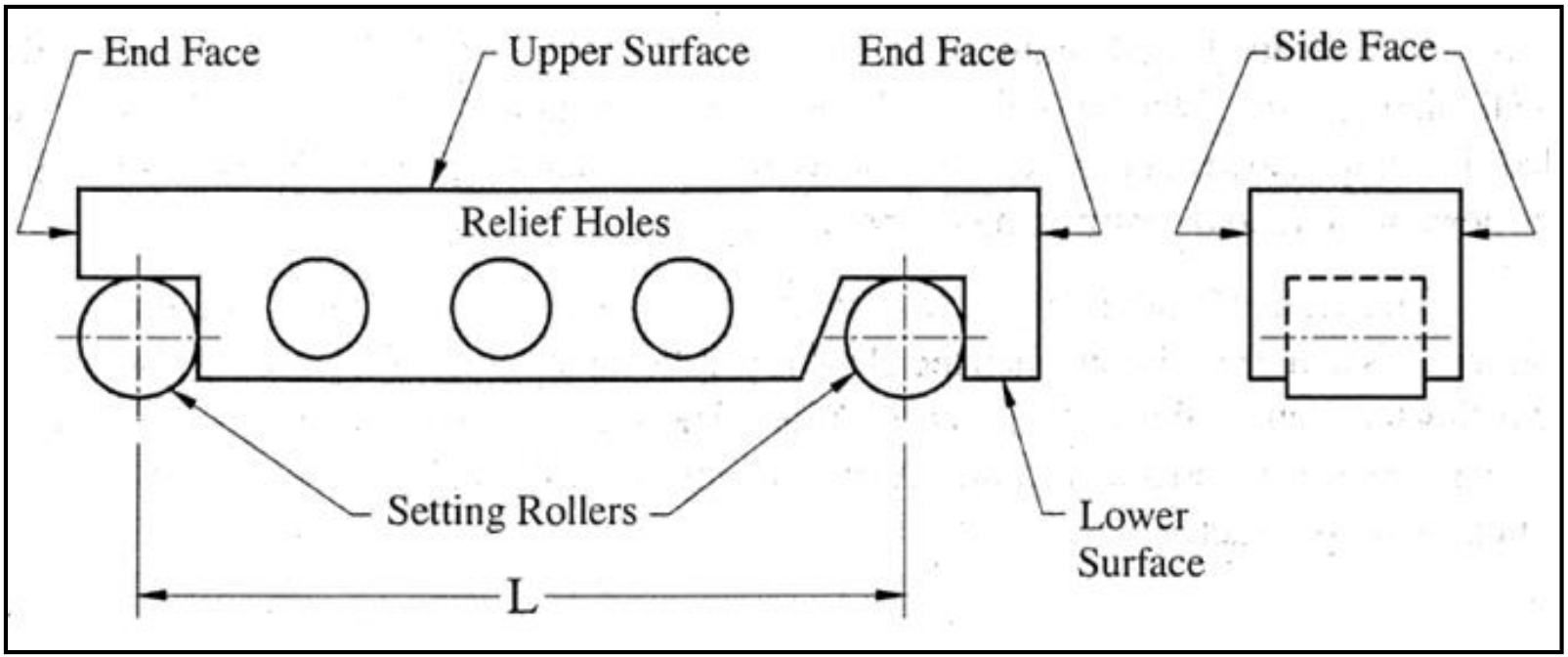




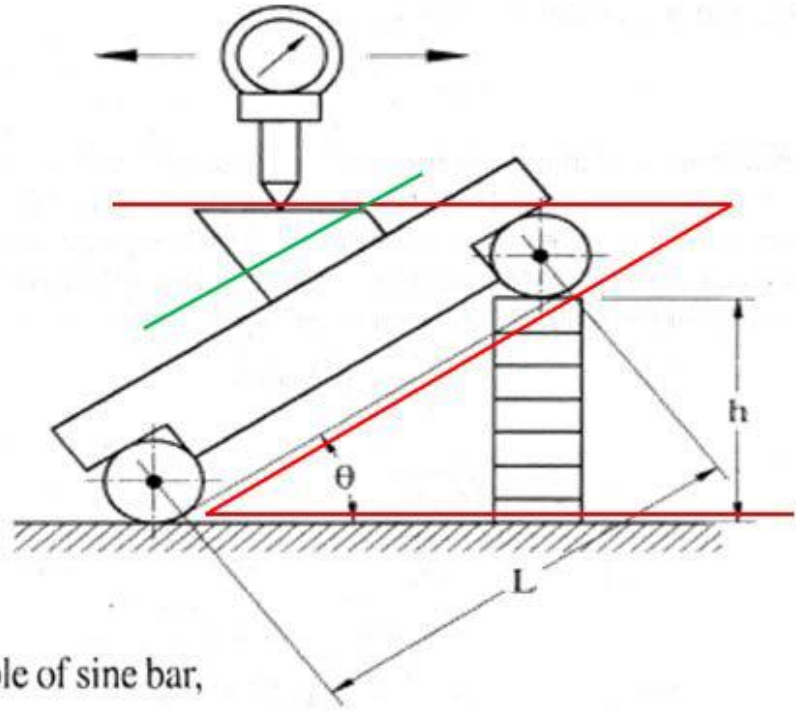




Sine bars



A precision angle measuring instrument used along with slip gauges



Measuring angle of small size component

Use of sine bar :

1. locating any work to a given angle :

As we have discussed in the working principle of sine bar,

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

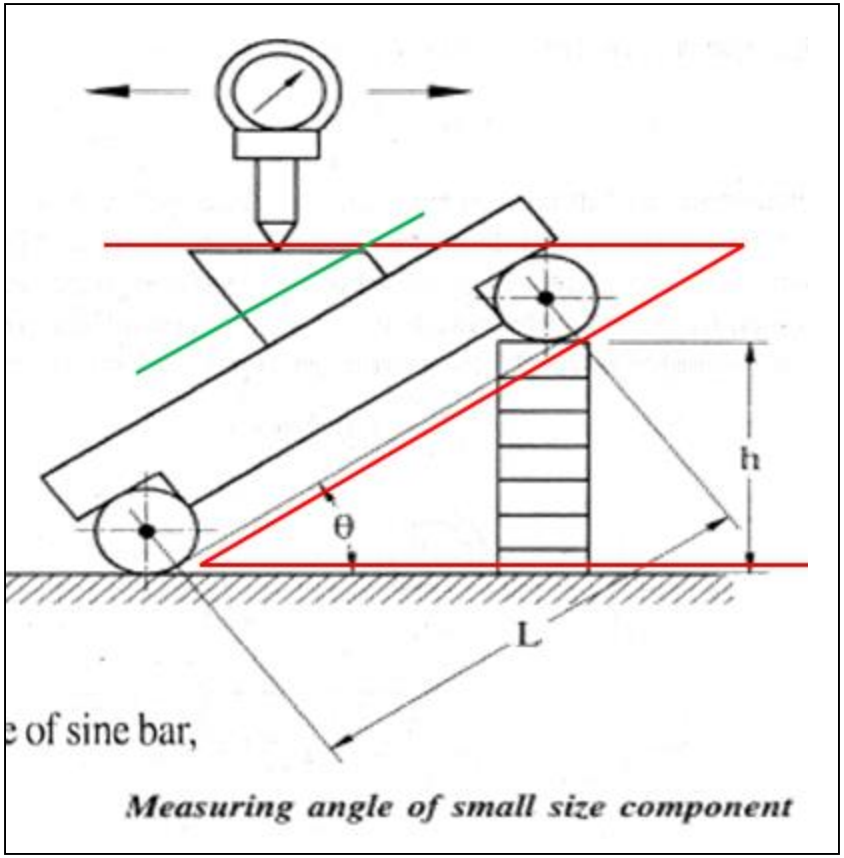
where, h be the height of slip gauge combination,

L is the distance between the centre of the rollers, and

θ is angle to be set.

Thus knowing θ, h can be found out and any work could be set at this angle; as the top face of the sine bar is inclined at angle θ to the surface plate. For better results, both the rollers could also be placed on slip gauges of height h_1 and h_2 respectively.

$$\sin\theta = \frac{h_2 - h_1}{L}$$



Measuring angle of small size component

The sine bars inherently become increasingly impractical and inaccurate as the angle exceeds 45° because of following reasons :

—The sine bar is physically clumsy to hold in position.

—The body of the sine bar obstructs the gauge block stack, even if relieved.

— Slight errors of the sine bar cause large angular errors.

— Long gauge stacks are not nearly as accurate as shorter gauge blocks.

—A difference in deformation occurs at the point of roller contact to the support surface and to the gauge blocks, because at higher angles, the weight load is shifted more toward the fulcrum roller.

—The size of gauges, instruments or parts that a sine bar can inspect is limited, since it is not designed to support large or heavy objects.

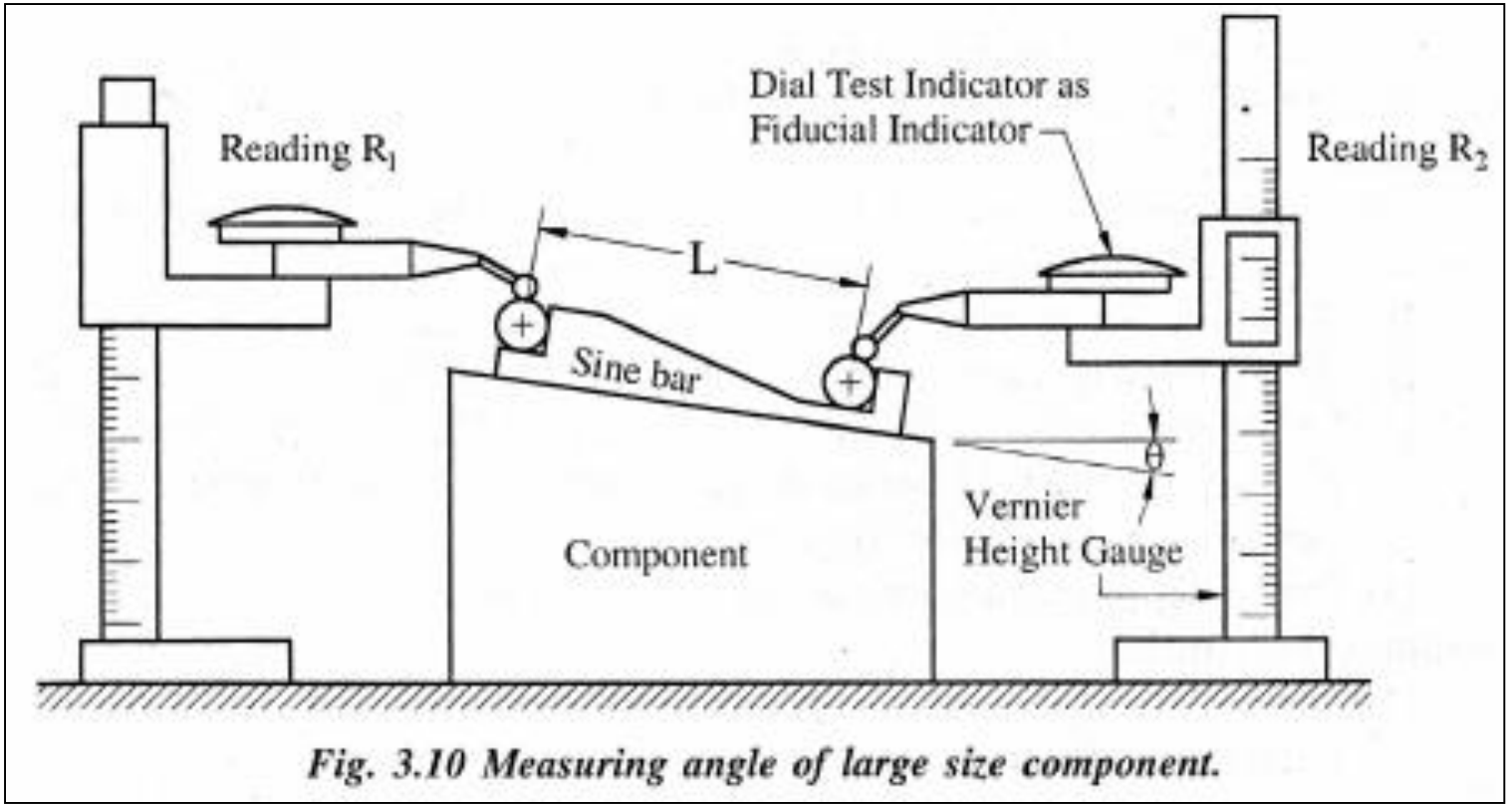


Fig. 3.10 Measuring angle of large size component.

Height over the rollers can be measured by a vernier height gauge; using a dial test gauge mounted on the anvil of height gauge to ensure constant measuring pressure.

•This is achieved by adjusting the height gauge until the dial gauge shows the same zero reading each time

$$\sin\theta = \frac{R_1 - R_2}{L}.$$

Sine bars

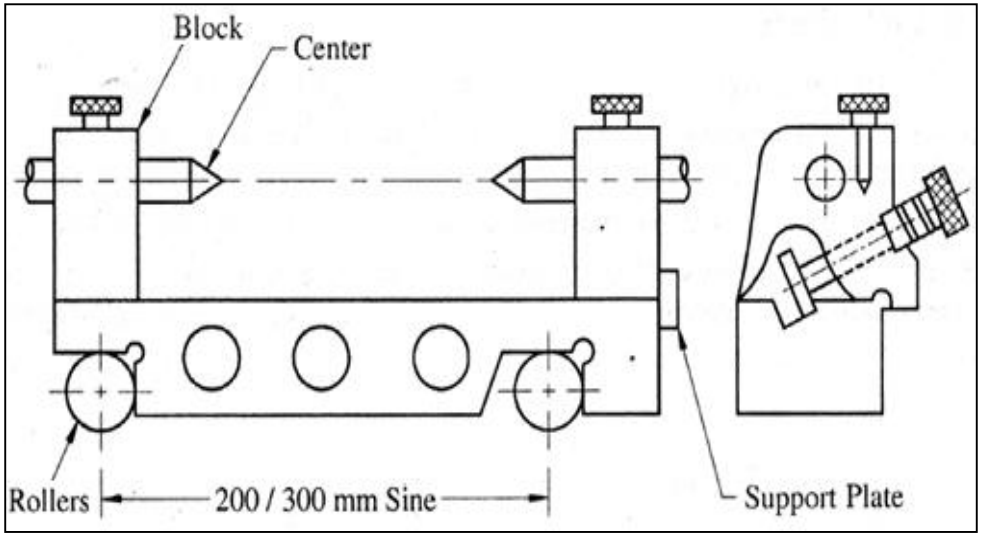
Advantages of sine bar :

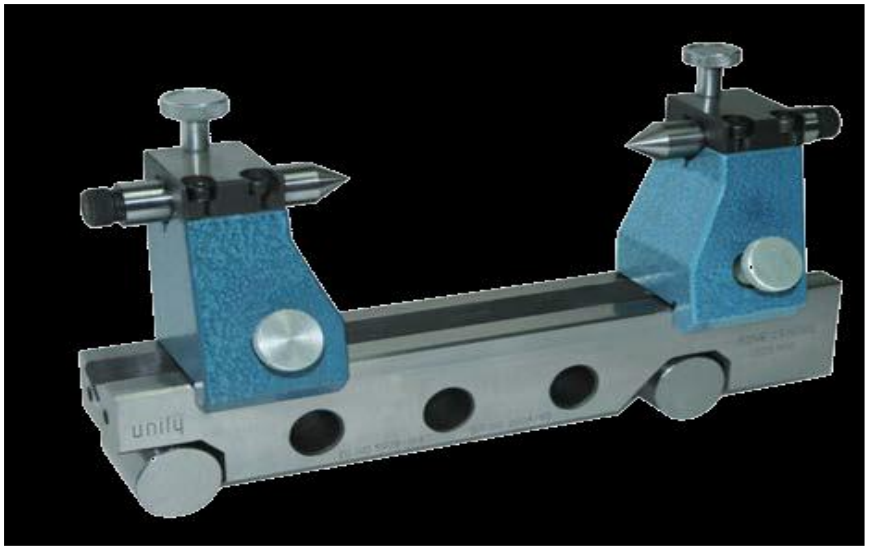
It is precise and accurate angle measuring device.
It is simple in design and construction.
It is easily available

Disadvantages :

It is fairly reliable at angles less than 15 but become increasingly inaccurate as the angle increases. It is impractical to use sine bar for angle above 45 .
It is difficult to handle and position the slip gauges.
The sine bar is physically clumsy to hold in position.
The application is limited for a fixed center distance between two rollers.
Slight errors of the sine bar cause larger angular errors.

Sine Centre

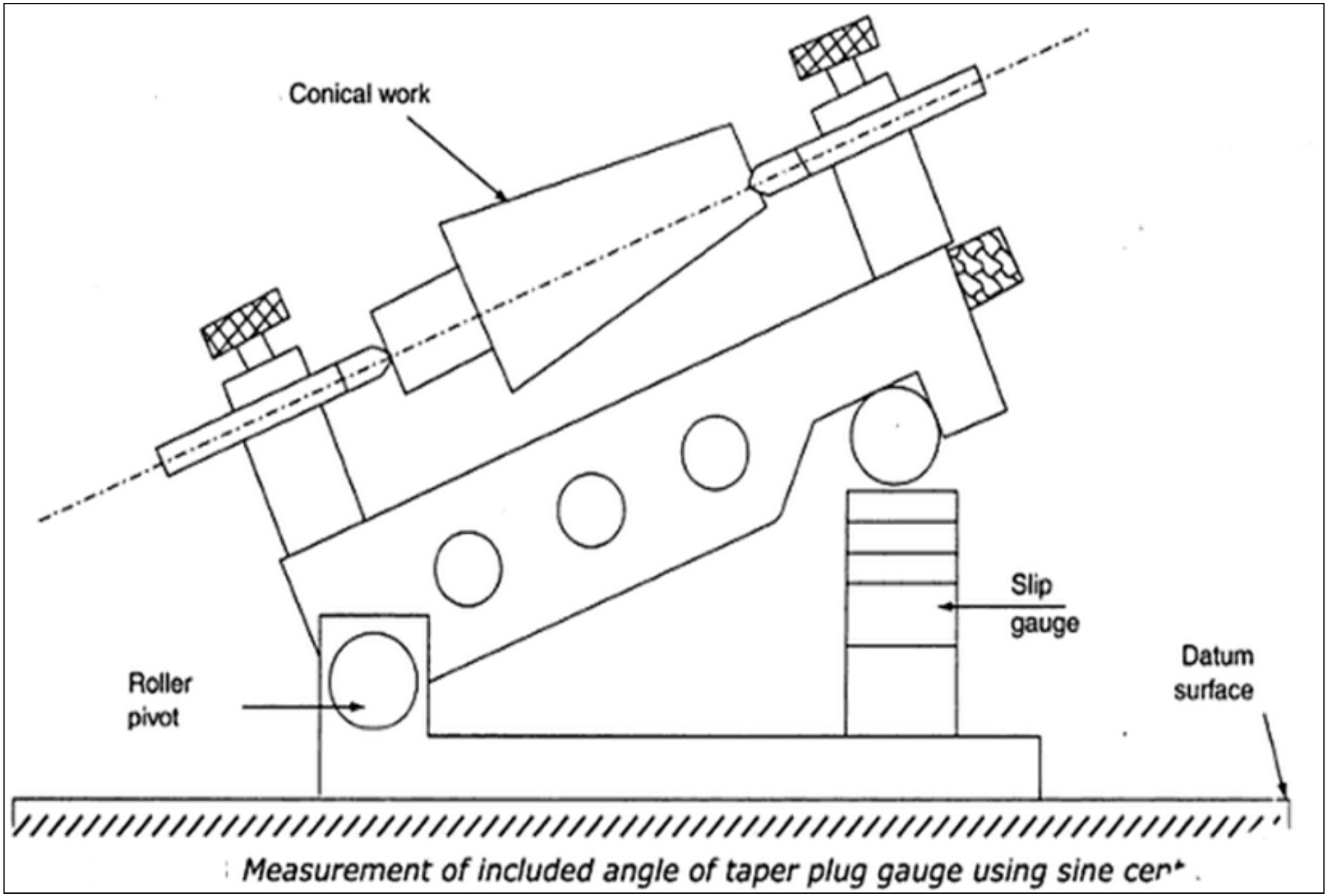




Sine center is basically a sine bar with block holding centers which can be adjusted and rigidly clamped in any position. used for the testing of conical work, centered at each end as shown.

Extremely useful since the alignment accuracy of the centers ensures that the correct line of measurement is made along the work piece.

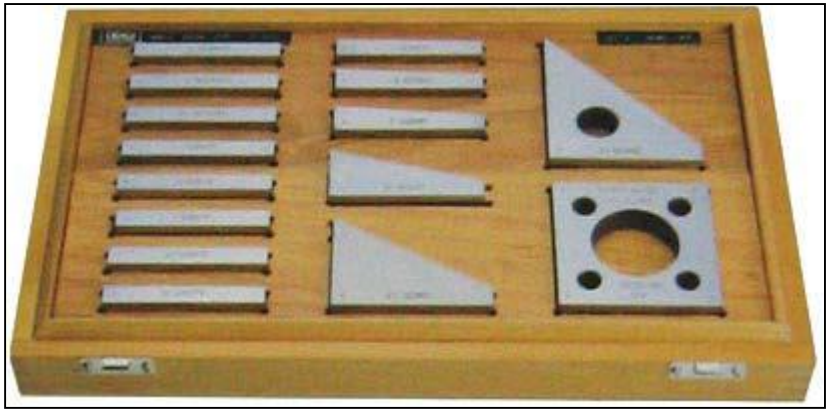
The centers can also be adjusted depending on the length of the conical work piece, to be hold between centers.



Measurement of included angle of taper plug gauge using sine cen

Angle Gauge

Angle gauges are made of hardened steel and seasoned carefully to ensure permanence of angular accuracy, and the measuring faces are lapped and polished to a high degree of accuracy and flatness like slip gauges.

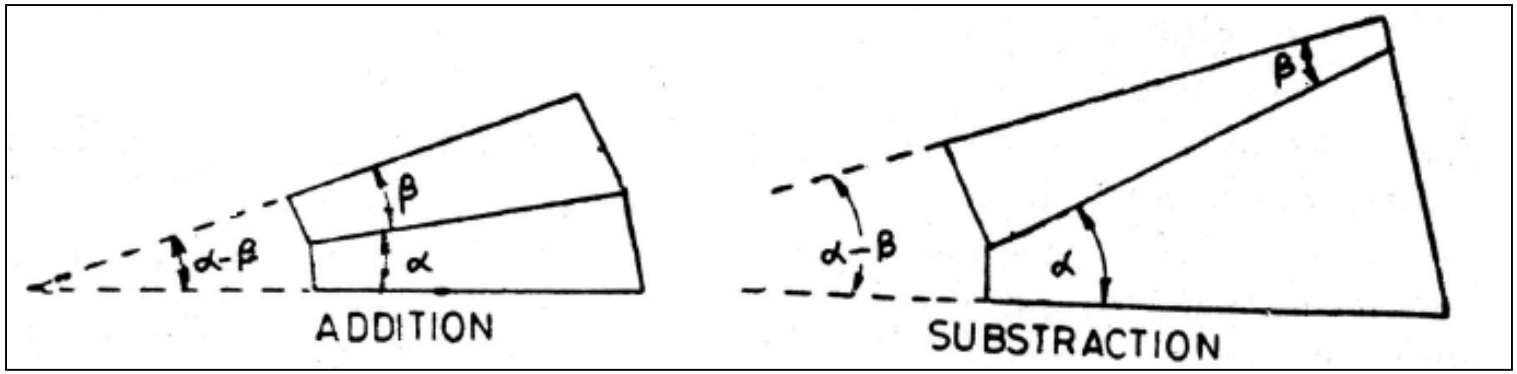


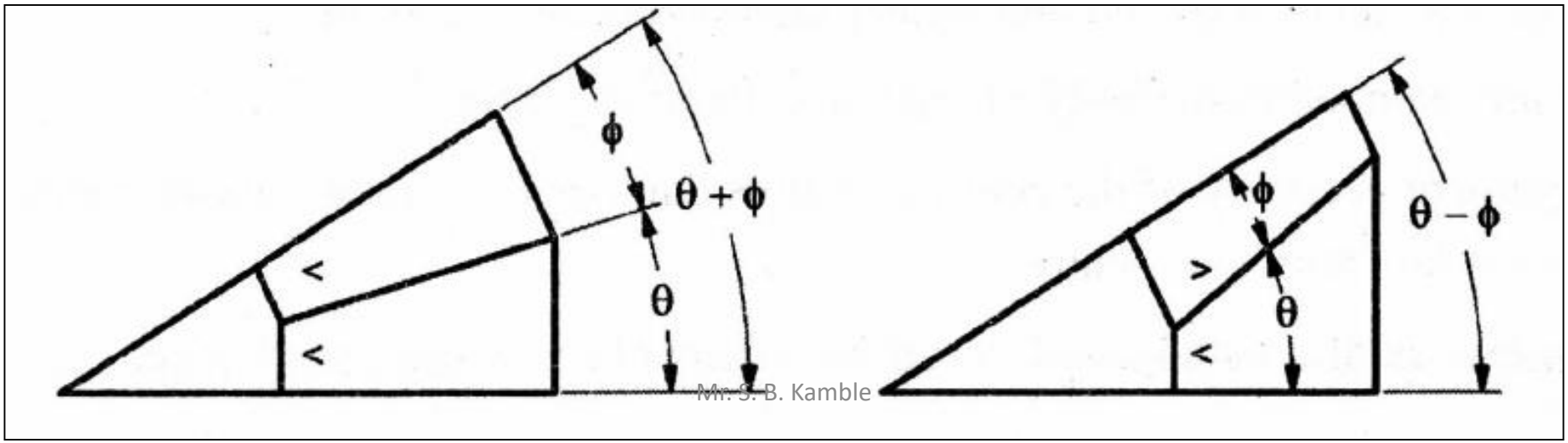
Angle Gauge

Like linear gauge blocks, angle gauge blocks can also be wrung together to build up a desired angle.

In addition, they can also be subtracted to form a smaller angle as a difference of two larger angles as shown in Figure.

The plus and minus ends of each block are marked.





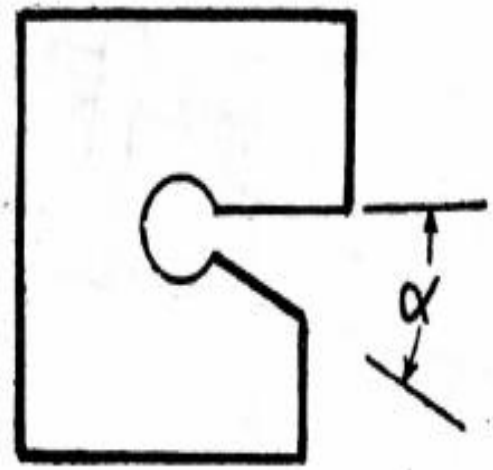
blocks provide a range of 0 to 90° – 59′ – 59″ in steps of one second .

13 piece set of angle gauge blocks has the following gauges.

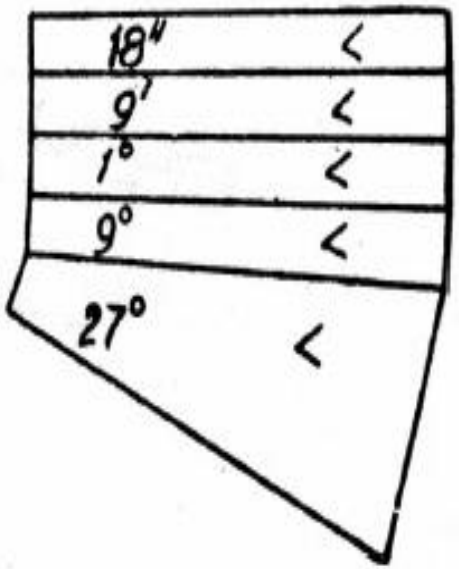
Degree blocks : 1, 3, 9, 27, 41°

Minute blocks : 1, 3, 9, and 27′

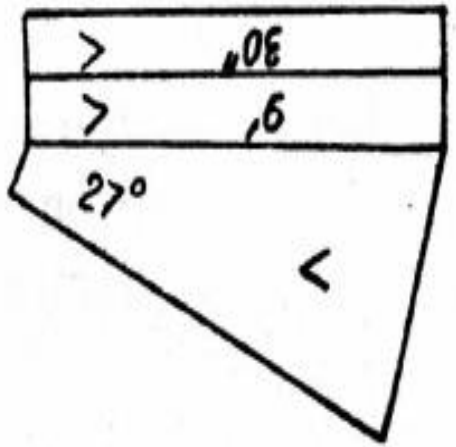
Second blocks : 3, 6, 18 and 30″



(a) Die insert



(b) All gauges added. Total angle = 37° 9′ 18″ (Not to scale)



(c) Angle set up = 27° minus 9′ 30″ = 26° 51′ 30″

blocks provide a range of 0 to 90° – 59′ – 59″ in steps of one second .

13 piece set of angle gauge blocks has the following gauges.

Degree blocks : 1, 3, 9, 27, 41°

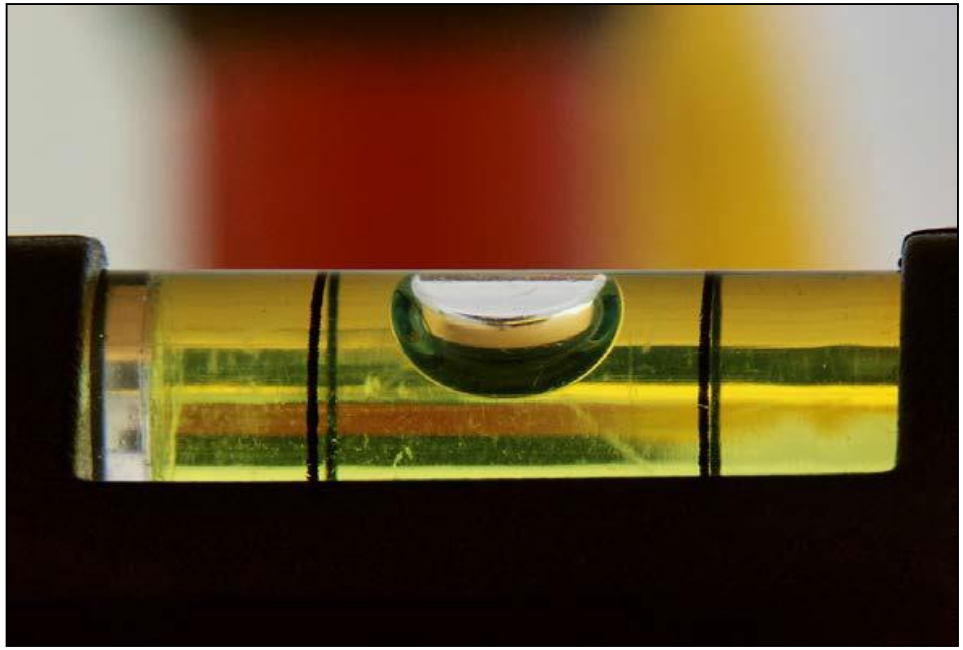
Minute blocks : 1, 3, 9, and 27′

Second blocks : 3, 6, 18 and 30″

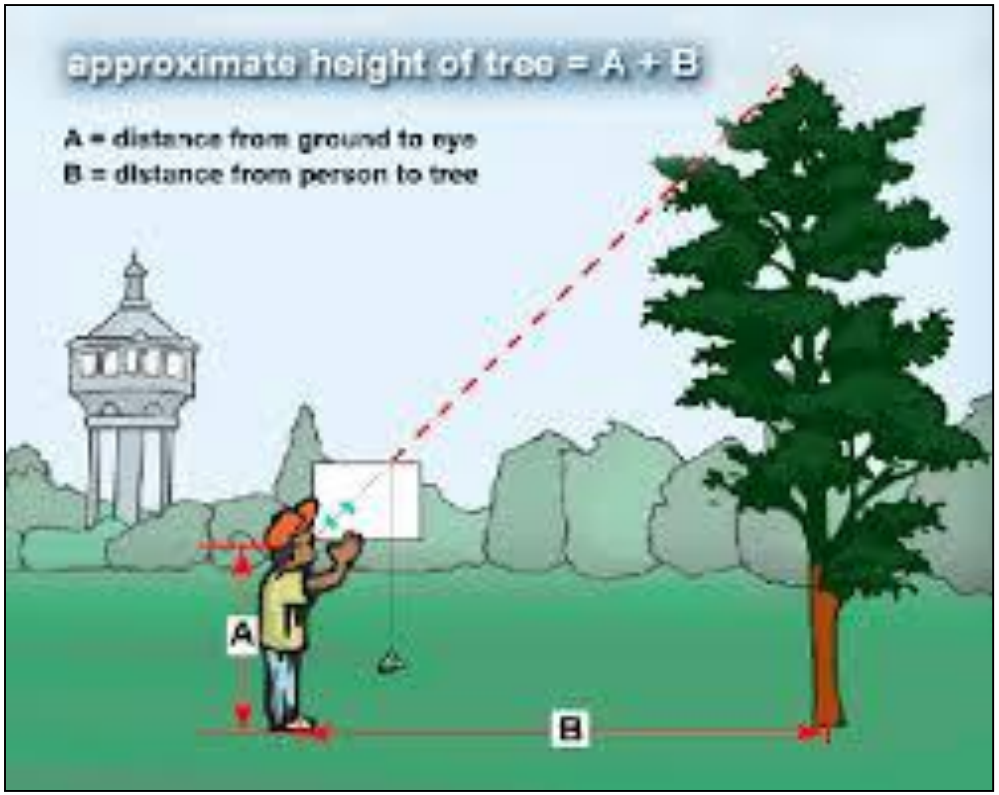
- Angle gauge blocks are commonly made of oil hardening tool steels, hardened to Rockwell C65 or Chrome steel with 85% chrome carbide and 15% nickel binder.
- They are available in two grades namely **laboratory master grade** and **tool room grade.**
- The characteristics of the two grades are as follows :

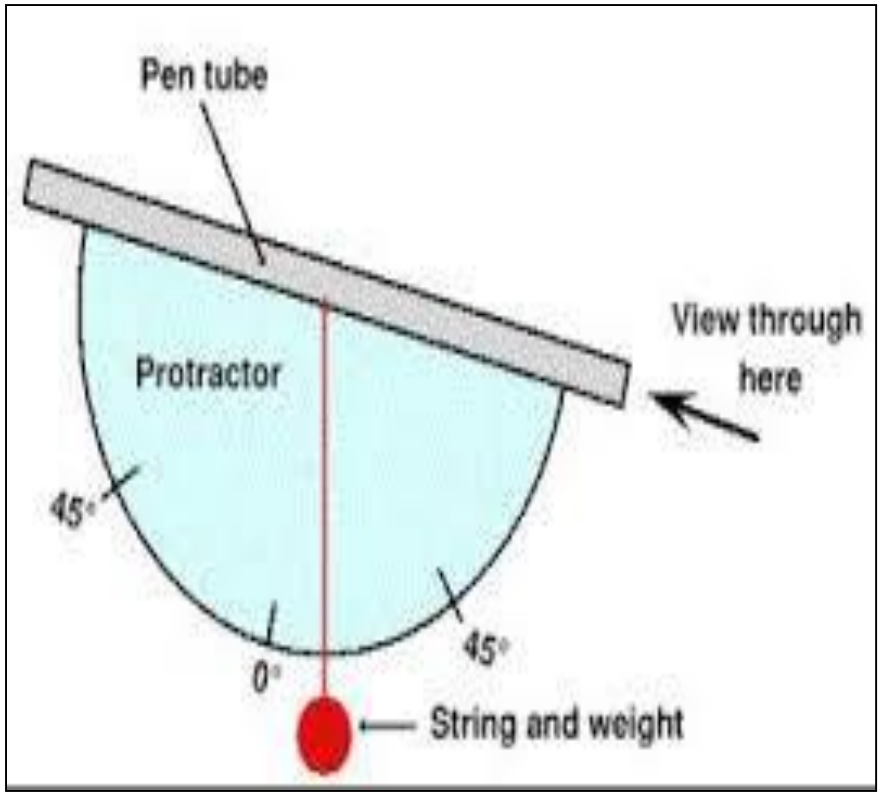
	Laboratory master grade (steel or chrome carbide)	Tool room grade (steel)
Deviation from marked angle	± 0.25 sec.	± 1 sec.
Flatness across width	0.00005 mm	0.0001 mm
Flatness along length	0.00005 mm	0.00015 mm
Parallelism of sides	0.00025 mm	0.00025 mm
Minimum surface finish RMS	0.000015 mm	0.000015 – 0.00002 mm

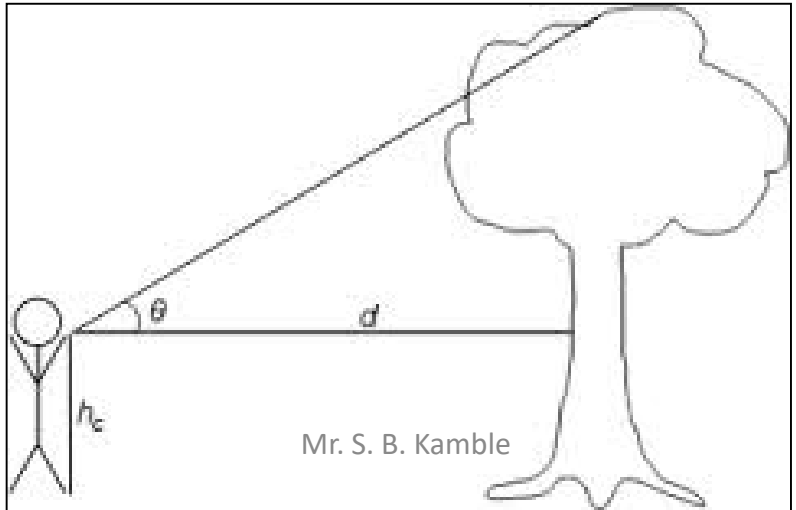
Spirit Level



Clinometers



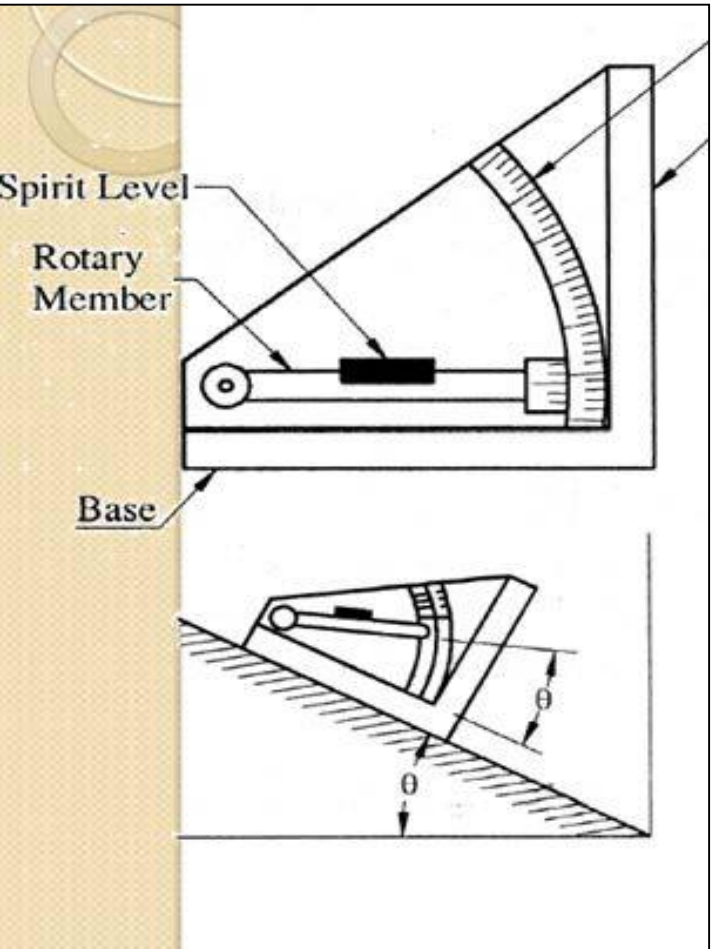




Clinometers

The clinometer is a special case of the application of the spirit level. It is an instrument used for measuring angle relative to the horizontal plane. The various types of clinometers are:

(1) Vernier clinometer.
(2) Micrometer clinometer.
(3) Dial clinometer.
(4) Optical clinometer.



It consists of a spirit level mounted on a rotary member carried in a housing.

•One face of the housing forms the base of the instrument

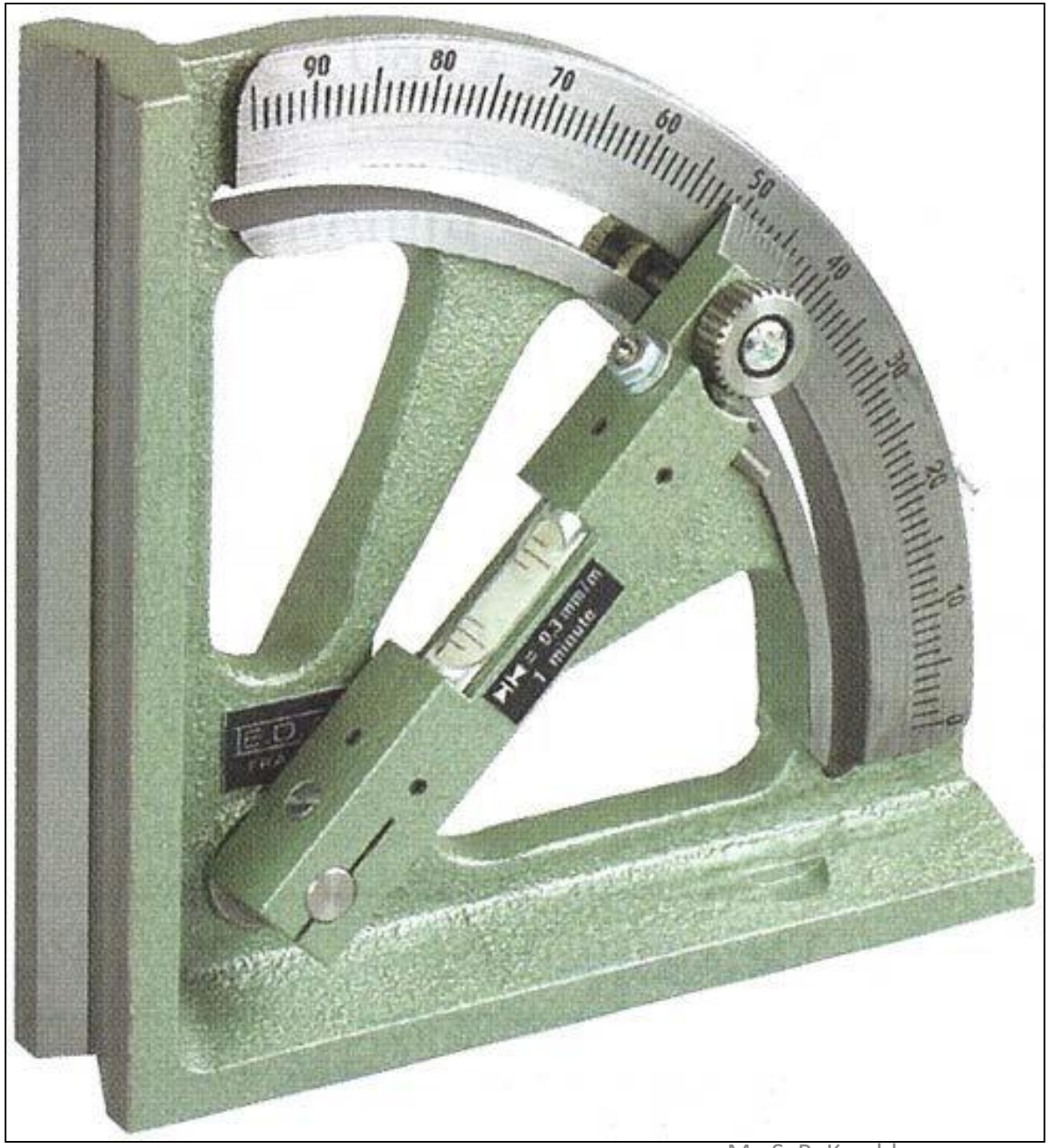
•A circular scale is provided on the housing.

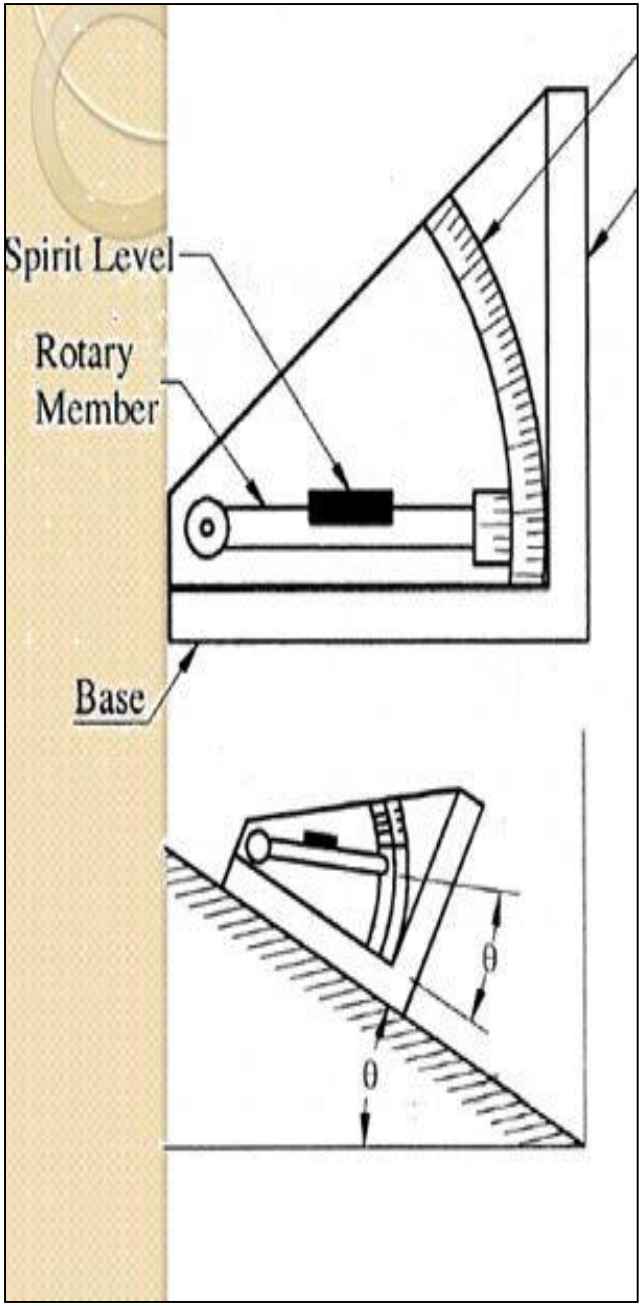
•A circular scale is used to measure the angle of inclination of the rotary member relative to the base.

•The scale may cover the whole circle or only part of it.

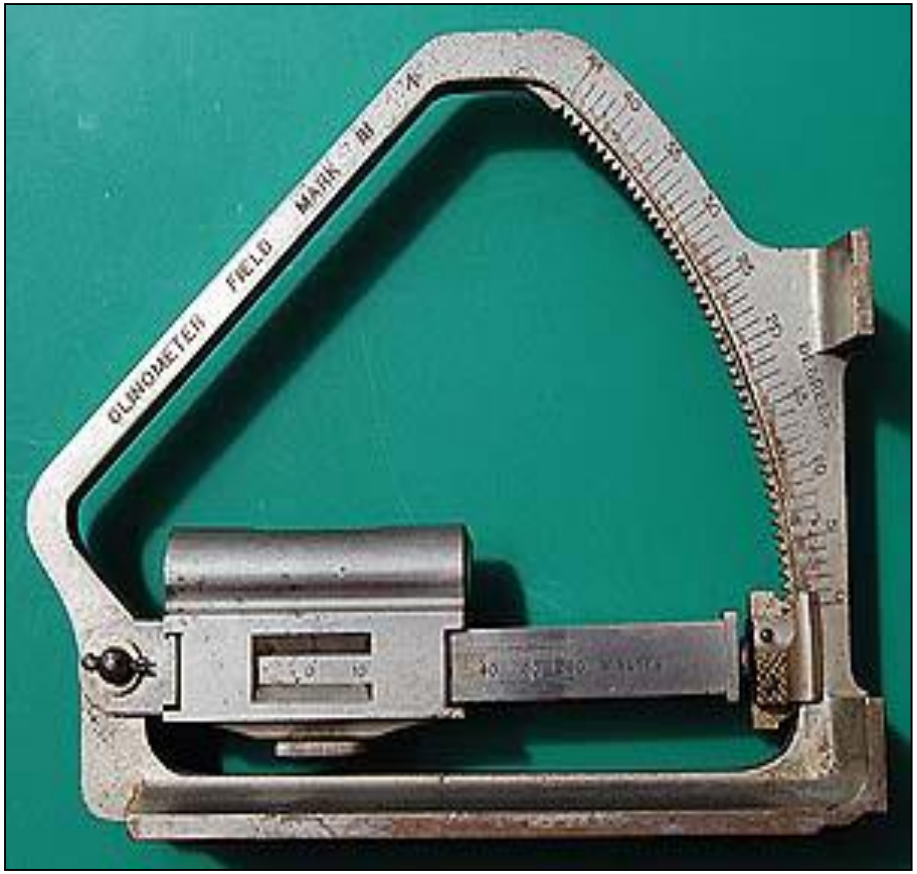
•The base of the instrument is placed on the surface and rotary member is adjusted till zero reading of the bubble is obtained as shown in Fig.

•The angle of rotation is then noted on the circular scale against an index.


90
80
70
60
50
40
30
20
10
0
1 minute


Spirit Level
Rotary
Member
Base
θ
θ


1Min.


CLINOMETER
FIELD

Micrometer clinometers is shown in Fig. In this type, one end of spirit level is attached at end of the barrel of a micrometer

The other end of the spirit level is hinged on the base. The base is placed on the surface whose inclination is to be measured.

•The micrometer is adjusted till the level is horizontal. This type of clinometers is suitable for measuring small angles.

The most commonly used clinometers is of the Hilger and Walts type in which circular, scale is totally enclosed and is divided from 0 to 360 at l0' interval. For observation of 10‘-subdivision optical micrometer is provided..