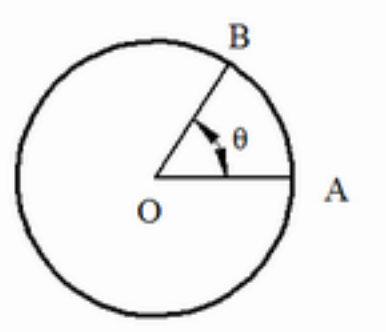
Chapter 3: ANGULAR MEASUREMENTS

Definition of Angle:

- Angle is defined as the opening between two lines which meet at a point.
- If a circle is divided into 360 parts, then each part is called a degree (^{o}).
- Each degree is subdivided into 60 parts called minutes(’), and each minute is further subdivided into 60 parts called seconds(”).

The unit ‘Radian’ is defined as the angle subtended by an arc of a circle of length equal to the radius.

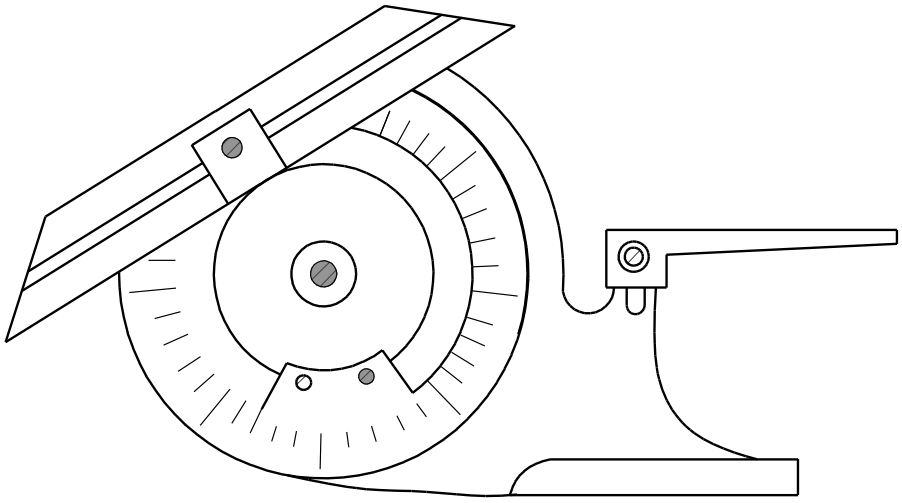
If arc AB = radius OA, then the angle q = 1 radian.

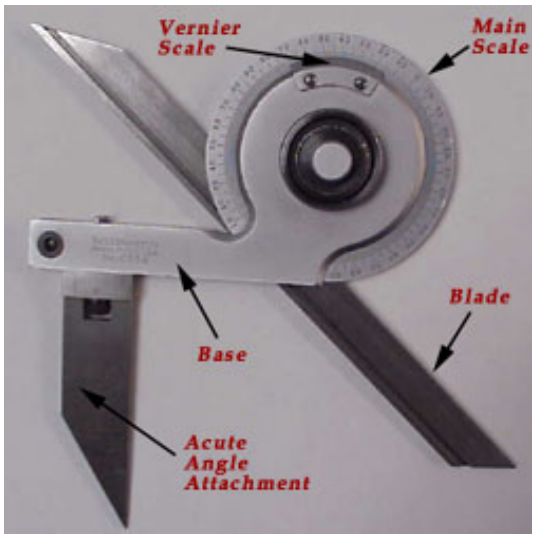


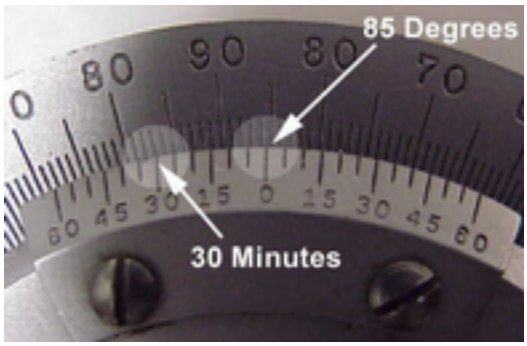
Vernier Bevel Protractor (Universal Bevel Protractor):

It is a simplest instrument for measuring the angle between two faces of a component.

It consists of a base plate attached to a main body and an adjustable blade which is attached to a circular plate containing vernier scale.







The adjustable blade is capable of sliding freely along the groove provided on it and can be clamped at any convenient length. The adjustable blade along with the circular plate containing the vernier can rotate freely about the center of the main scale engraved on the body of the instrument and can be locked in any position with the help of a clamping knob.

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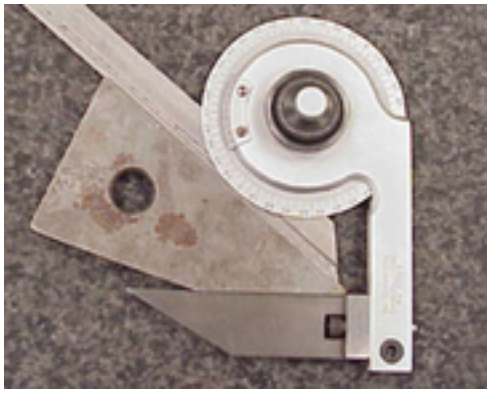
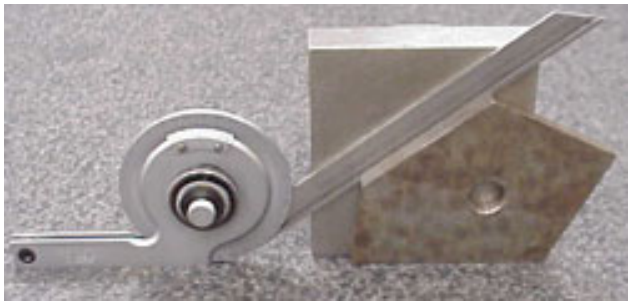
The main scale is graduated in degrees. The vernier scale has 12 divisions on either side of the center zero. They are marked 0-60 minutes of arc, so that each division is 1/12th of 60 minutes, i.e. 5 minutes. These 12 divisions occupy same arc space as 23 degrees on the main scale, such that each division of the vernier = (1/12)*23 = 1(11/12) degrees.



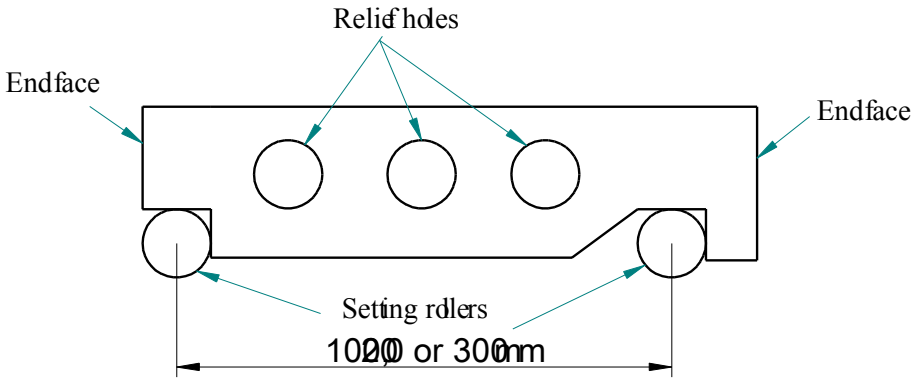


ACUTE ANGLE MEASUREMENT OBTUSE ANGLE MEASUREMENT

If the zero graduation on the vernier scale coincides with a graduation on main scale, the reading is in exact degrees.

If some other graduation on the vernier scale coincides with a main scale graduation, the number of vernier graduations multiplied by 5 minutes must be added to the main scale reading.

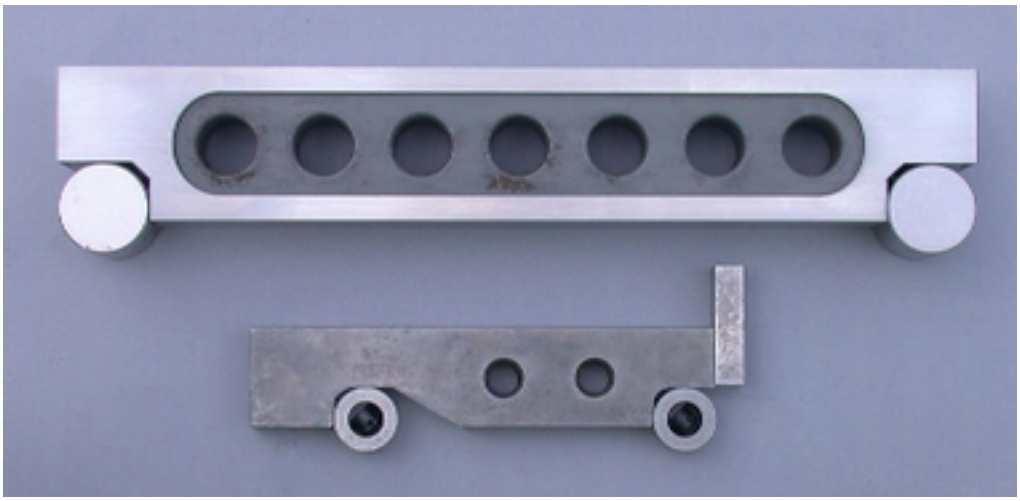
Sine Bar



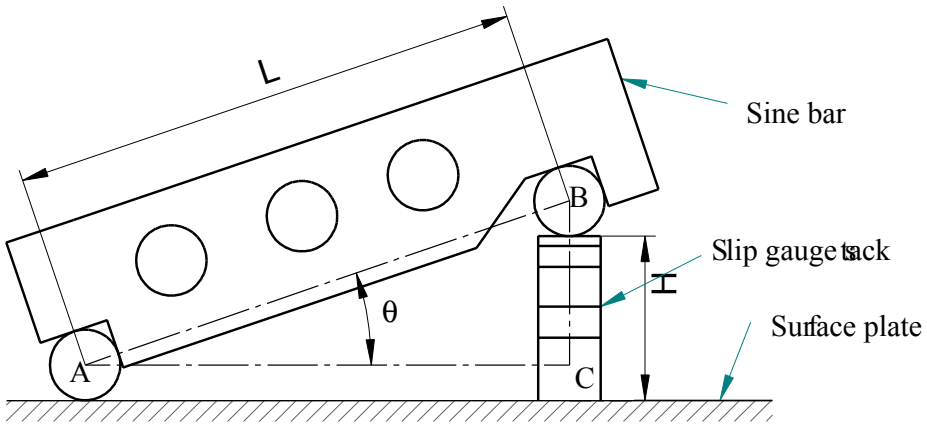
SIMPLE FORM OF SINE BAR

Sine bars are made from high carbon, high chromium, corrosion resistant steel which can be hardened, ground & stabilized. Two cylinders of equal diameters are attached at the ends as shown in fig. The distance between the axes can be 100, 200 & 300 mm.

The Sine bar is designated basically for the precise setting out of angles and is generally used in conjunction with slip gauges & surface plate. The principle of operation relies upon the application of Trigonometry.

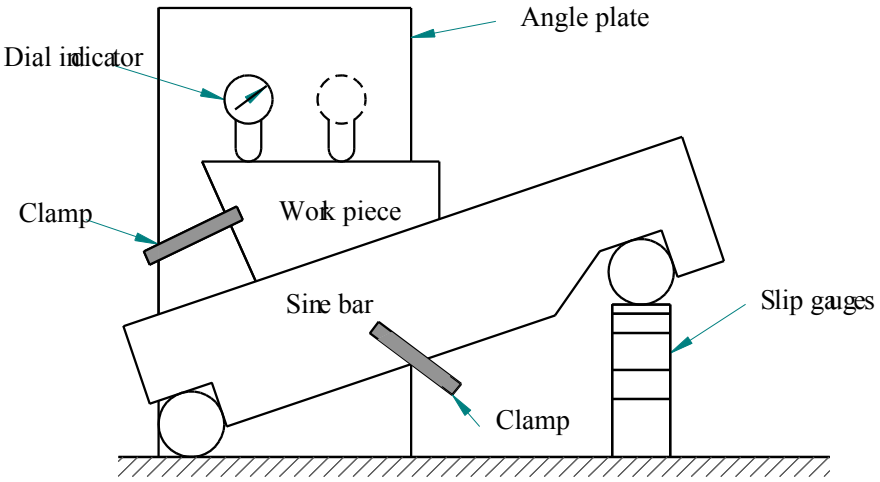


In the above fig, the standard length AB (L) can be used & by varying the slip gauge stack (H), any desired angle θ can be obtained as, θ=sin-1(H/L)



Sine Bar

For checking unknown angles of a component, a dial indicator is moved along the surface of work and any deviation is noted. The slip gauges are then adjusted such that the dial reads zero as it moves from one end to the other.



Limitations of Sine bars:

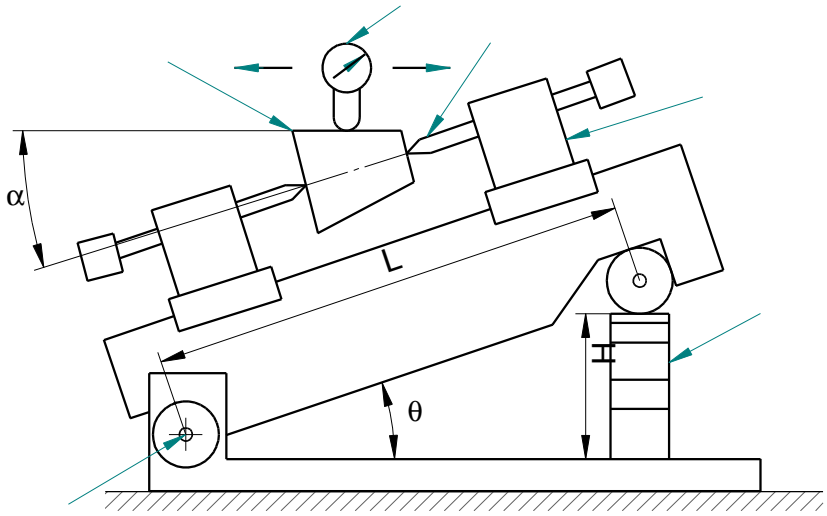
The accuracy of sine bars is limited by measurement of center distance between the two precision rollers & hence it cannot be used as a primary standard for angle measurements.

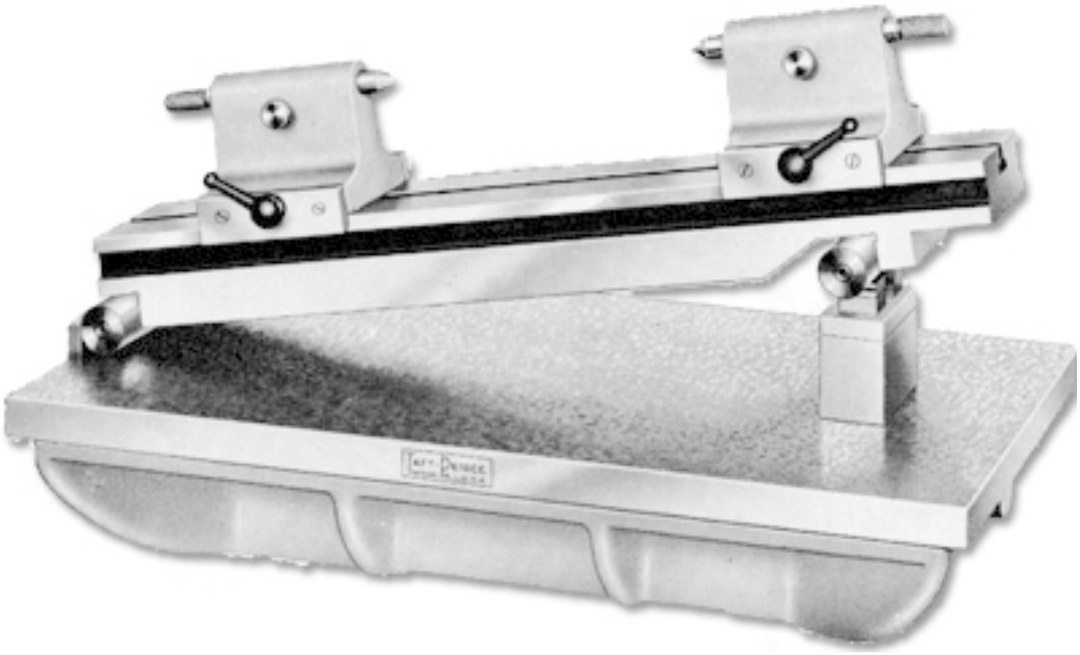
Sine principle is fairly reliable at angles less than 15°, but becomes inaccurate as the angle increases.

For angles exceeding 45°, sine bars are not suitable for the following reasons:

1. The sine bar is physically clumsy to hold in position.
2. The body of the sine bar obstructs the gauge block stack, even if relieved.
3. Slight errors of the sine bar cause large angular errors.
4. Long gauge stacks are not nearly as accurate as shorter gauge blocks.
5. A difference in deformation occurs at the point of roller contact supporting the surface and to the gauge blocks, because at higher angles, the load is shifted more towards the fulcrum roller.

Sine center:

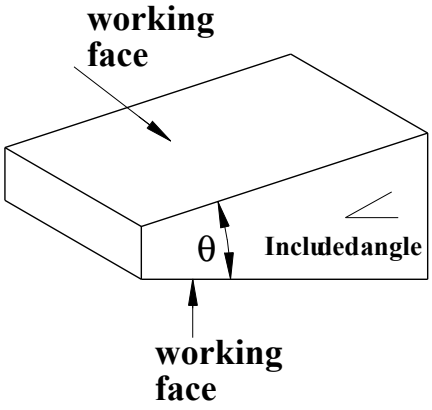




Sine centers are used for mounting conical work pieces which cannot be held on a conventional sine bar. Sine center consists of a self-contained sine bar hinged at one roller and mounted on its own datum surface & the top surface of the bar is provided with clamps & centers to hold the work. For the dial gauge to read zero, the accurate semi cone angle $\alpha=\theta=\sin^{-1}(H/L)$.

Angle Gauges:

These were developed by Dr. Tomlinson in 1939. The angle gauges are hardened steel blocks of 75 mm length and 16 mm wide which has lapped surfaces lying at a very precise angle.



The engraved symbol '<' indicates the direction of the included angle. Angle gauges are available in a 13 piece set.

Deg	**1**	**3**	**9**	**27**	**41**
Min	**1**	**3**	**9**	**27**	
sec	**3**	**6**	**18**	**30**	

These gauges together with a square block enable any angle between 0^0 & 360^0 to be built within an accuracy of 1.5 seconds of the nominal value. The wringing is similar to that of slip gauges.

Numericals on building of angles:

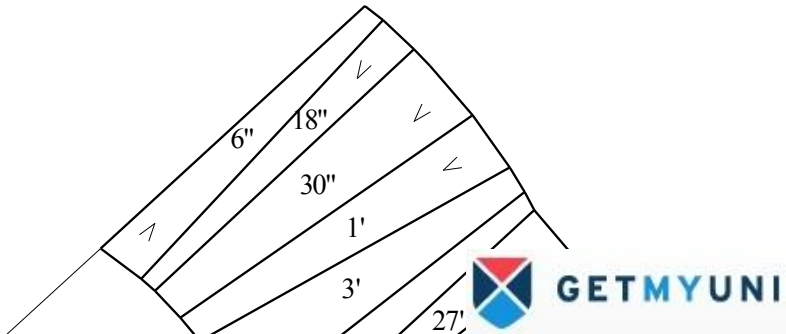
The required angle may built by wringing suitable combination of angle gauges similar to that of slip gauges. Each angle is a wedge and thus two gauges with narrow ends together provide an angle which is equal to the sum of angles of individual gauges. Two gauges when wrung together with opposing narrow ends give subtraction of the two angles.

Numerical 1:

Build an angle of 37º 16' 42" using angle gauges.

Solution:

Degree $27^o + 9^o + 1^o = 37^o$

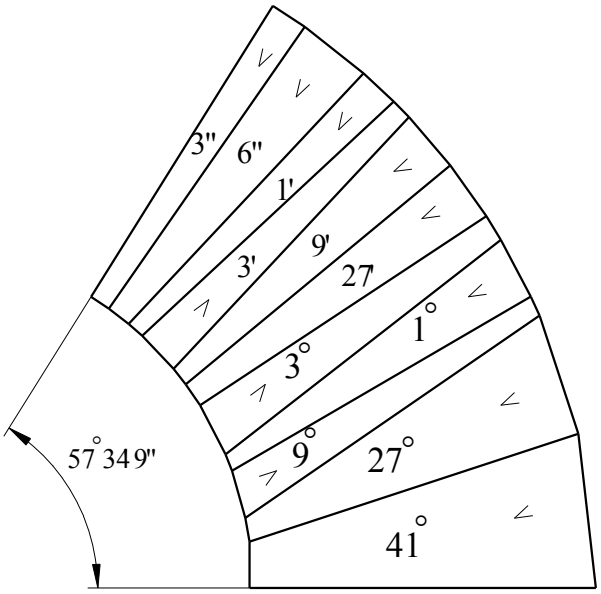


Minutes = 27'-9'-3'+1' = 16'

Seconds = 30"+ 18" -6"= 42"

Numerical 2:

Build an angle of 57° 34' 9"



Solution:

Degree = 41° +27° -9° +1°-3° =57°

Minutes = 27'+9'-3'+1' = 34'

Seconds = 6"+ 3" =9"

Numerical 3:

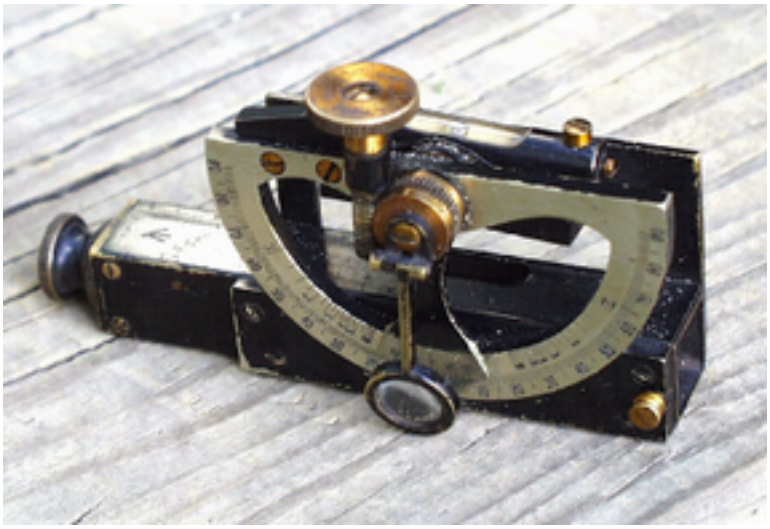
Give the combination of angle gauges required to build 102° 8' 42"

Degree: 90° +9° +3° =102°

Minutes: 9'-1' = 8'

Seconds 30"+ 18"- 6" =42"

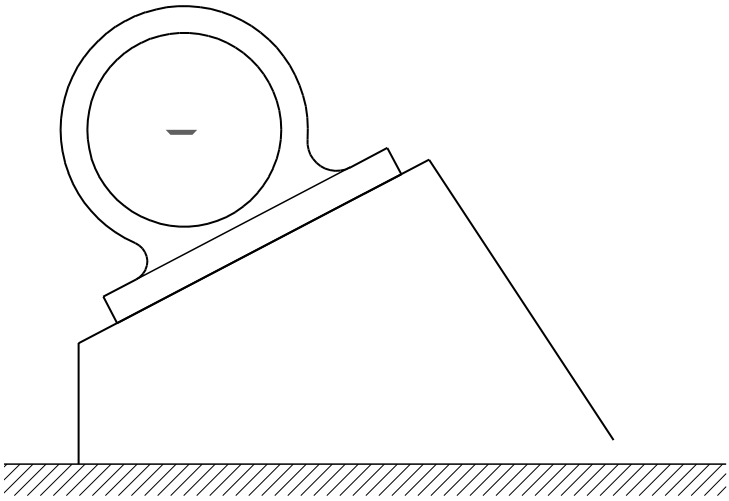
CLINOMETER



A Clinometer is a special case of application of spirit level, in which it is mounted on a rotary member carried on housing. A semicircular scale is used to measure the angle of inclination of the rotary member carrying the spirit level relative to its base.

Clinometer is mainly used to

the workpiece.



The Clinometer is first placed on one face of the workpiece and the rotary member is adjusted till the bubble is exactly at the center of the spirit level. The angle is noted on the scale. A second reading is taken in a similar manner on the second face of the workpiece. The included angle is then the difference between the two readings.

i.e. from fig, $\gamma=180-(\alpha+\beta)$.

Clinometers are used for checking face & relief angles on large cutting tools & milling cutter inserts. Also they are used for setting jig boring machine tables & angular work on grinding machines.