

Metrology = Measurement

* Engineering Metrology :-

Metrology (Measurement) is a science of Measurement. Engineering Metrology may be defined as the branch of science in which measurement related to engineering is done. It is deals measurement of length, angle and other quantities which are expressed in terms of an angles.

* Error in measurement :- Error in measurement occurs due to following :-

- 1) Error in unit of measurement and standard.
- 2) Method of measurement.
- 3) Measuring instrument.
- 4) accuracy of process.

* Legal metrology :- Legal metrology is direct by a national organisation which is called national institute of legal metrology. It includes a number of international organisation whose ultimate object is to maintain uniformity of measurement throughout the world.

Its function are as follows :-

- 1) To ensure conservation of national standards.
- 2) To detect errors in measurement.

- 3) To organise remaining in legal metrology.
- 4) To ensure accuracy of standards & measuring instruments.

Inspection: Inspection is the act of comparing material, product or performance with established standards.
or • Inspection means checking of materials, products or component parts at various stages during manufacturing.

Need of inspection:-

- 1) To ensure that the part, material or a component conforms to the established standard.
- 2) To meet the interchange ability of manufacture.

- 3) To maintain customer relation.
- 4) It also help to purchase good raw material.
- 5) To take decision on the defective parts.

⇒ Types of inspection:-

(A) On the basis of location:-

- 1) Centralized Inspection.
- 2) Decentralized inspection.

(B) On the basis of the Process:-

- 1) Trial and run Inspection.
- 2) First test Inspection.
- 3) Pilot Piece inspection.
- 4) In Process Inspection.
- 5) Operation Inspection.
- 6) Sampling Inspection.
- 7) Final Inspection.
- 8) Key operation inspection.
- 9) Final Assembly Inspection.

(A)

① Centralized Inspection:- In this type of inspection system a single inspection room for the whole plant or each section.

Product from each section are inspected in this central inspection unit are located here. The inspection staff has to be more experienced in this system.

In this manufacturing is separated from inspection which eliminates obstruction.

:- Advantages:- 1) No chance of collusion between inspection and production.

2) Less space is used.

3) Less number of gauges and instruments are

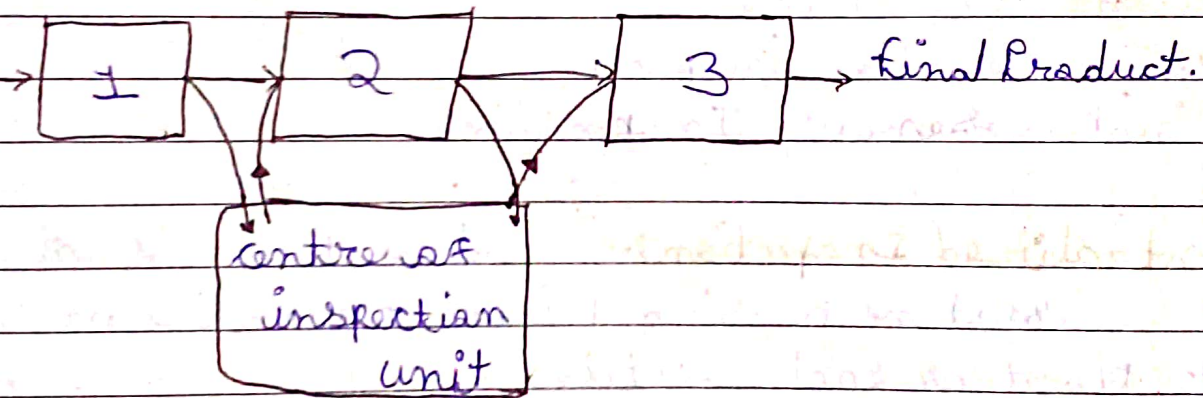
required.

- 4) Mass Production is easier.
- 5) Less costly.

Disadvantage:- 1) Material handling is increase.
2) Process is slow.

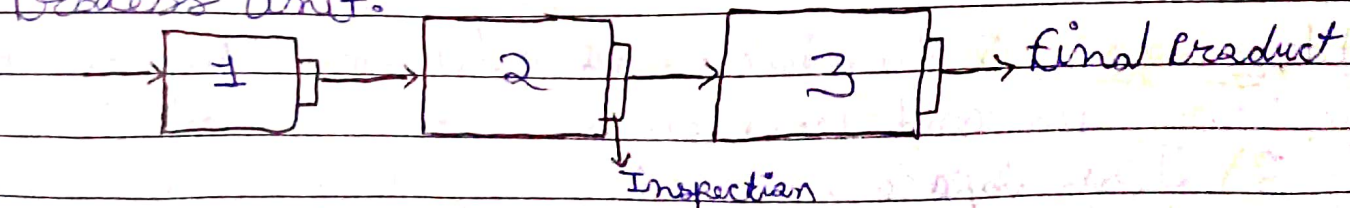
3) More planning and control is required.

4)



(A) (2) Decentralized:- In this type of inspection the interm are inspected either on the same machine all in the same production line after the process.

A separate inspection unit is there after every process unit.



Advantages:- 1) fast inspection.

2) less material handling.

3) suitable for heavy products like boiler or parts etc.

ship parts etc.

4) Plant layout and mass production can be "easily achieve".

Disadvantage:- 1) Area requirement is more.

3) earlier than centralized inspection.

3) Production time may be effected.

4) Inspectors may be influenced by the ~~test~~ markers

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* Specification: It provide specific or additional requirements for the material component or services which are other than the standard requirements.

:- Need of specification :-

① It help differentiating the component.

② It gives complete information of the product.

③ It help gives cost saving the Product.

* Assembly: The process of putting together different parts to make final product is known as assembly.

Types of Assembly:-

- 1) Trial & Error assembly.
- 2) Interchangeable Assembly.
- 3) Selective Assembly.

① Trial & Error assembly:- In this, size a small number of similar operator and the required fit is obtained by trial and error method. The operator first make one of the part as accurate as possible then the other part is machined with a small amount at a time until the ~~first~~ fit obtained.

This method may be used for "one off jobs" such as crankshaft etc. Where both parts will be replaced at once.

② Interchangeable assembly:- When a large number of components are to be produced then it will not be economical to produce both the mating components by the same operator.

③ Selective assembly:- It is sometimes found that it is not economical to manufacture parts to the required high degree of accuracy so as to make them interchangeable.

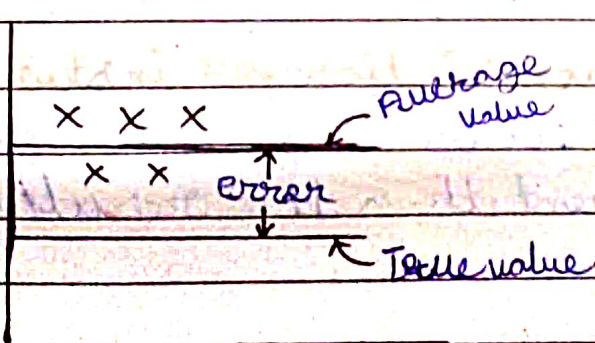
- ⑧ 1) Trial and run inspection:- In this kind of inspection which is also called tool inspection the tools, jigs, fixtures and machines are checked in advance according to specification before the commencement of operation.
- 2) First AFA inspection:- The products manufactured in the first production run are inspected and checked with respect to specification thoroughly. This technique is normally followed in case where automatic machines are employed for production and if the first production run is found satisfactory.
- 3) Pilot piece inspection:- This kind of inspection is applicable for product type or layout. The product in this case shall pass through entire sequence of operation on a series of machines installed for the production purposes.
- 4) In Process inspection:- This type of inspection is also known as marking inspection and in this inspection products should be inspected while they are in process to see that they are being produced according to specifications.

- 5) Operation inspection:- This type of inspection is employed at the completion of a operation before the item/component passes to next operation / machine or department.
- 6) Sampling inspection:- From the inspection result at certain percentage from a lot, the entire lot can be judged.
- 7) Final inspection:- This type of inspection ~~result~~ ~~at certain~~ is employed ~~with~~ when the manufacturing process is complete and the article is to be sent to store.
- 8) Key operation inspection:- There are certain operation in the manufacturing of a product which are costly and difficult and operators often commit mistake in those operations. Such operation are known as key operation.
- 9) Final Assembly inspection:- It is also known as functional inspection and it is carried out after the completion of the product assembly to check the accuracy of the assembly and its functioning.

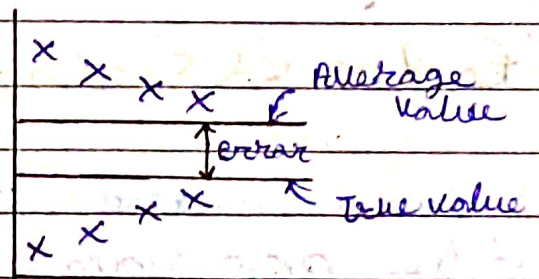
* Accuracy and Precision

(i) Accuracy :- Accuracy is the degree to which the measured value is same as its true value. the difference between measured value and true value is known as error. higher the error lower will be accuracy.

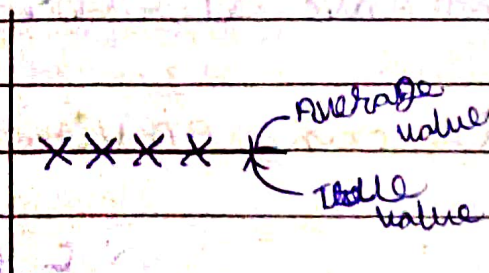
(ii) Precision :- Precision is the repeatability of the measuring process it refers to a group of measurements of same product under same or identical condition. if all the readings are same then the process is called precise.



(i) Precision but not accurate.



(ii) Accurate but not precise.



(iii) Accurate and precise both.

Factor affecting accuracy:-

↓
SWIPE

Standard, Workpiece, Instrument, Person, Environment.

- 1) Factor affecting standards:- If the standard is affected then the result is not accurate.
- 2) Factor affecting workpiece:- If the work piece has surface defects scratches, hidden, geometric then the result will not be accurate.
- 3) Factor affecting characteristics of instrument:- If there is any error already present in the instrument then the result will not be accurate.
- 4) Factor affecting person:- If the person does not have sufficient skill.
- 5) Factor affecting environment:-
If the environmental characteristics like :- Pressure, temperature,

is change then the accuracy is affected.

If any of the above characteristics is changed then the accuracy of the measurement will be affected.

Unit - 3 completed?

Unit - 2

Linear measurement

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It is measurement of length, diameter, height, thickness etc. including internal and external measurement.

It has ~~some~~ ~~series~~ ~~of~~ accurately spaced lines marked on them. This are either line measurement (scale) or end-to-end measurement (Vernier caliper, micrometer). It can be classified as following:-

* ¹⁾ Direct measurement:-

- ① Graduated:- ex:- 1) scale, Vernier, micrometer.
- ② Non-graduated:- ex:- 1) slip gauge, 2) caliper.

* 2) Indirect measurement:- can also be defined as:-
1) Non-precision instrument, steel rule etc.
2) Vernier, Precision.

Different measuring instrument:-

- | | | |
|-----------------|-----------------|------------------|
| 1) Steel rule | 2) caliper | 3) surface plate |
| 4) spirit level | 5) Radius gauge | 6) Feeler gauge |
| 7) wire gauge | 8) Vernier | 9) Micrometer. |

1) steel rule → A steel rule is a measuring tool with a straight edge and marking along it that is used to measure length, width or

depth.

2) Calliper :- A calliper is a measuring tool that measures the length, width, thickness, diameter or depth of an object. It is used in many fields such as engineering, metallurgy, woodworking.

3) Surface Plate :- A surface plate is a solid, flat plate used as a horizontal reference location for dimensional measurements.

4) Spirit Level :- A spirit level is a measuring instrument that first shows whether a surface is horizontal or vertical.

5) Radius gauge :- A Radius gauge is a measuring instrument with which the radius of an object is measured. It is also called fillet gauge. It is used to check the inner and ~~outer~~ outer radius of an object. The passage of light between the gauges and the work allows the radius to be checked properly.

6) feeler gauge:- A feeler gauge is a device that measures the distance or gap between two parts. It is mostly used in engineering it is also called gap gauge.

7) wire gauge:- A wire gauge is a way of measuring that diameter or thickness of a wire. It indicates the wire's ability to carry electrical current, electrical resistance and weight. Wire gauge is also known as American wire gauge (AWG).

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Assignment 1

8) Vernier caliper:- The vernier caliper consists of two scales: one is fixed and the other is movable. The fixed scale called main scale is calibrated on L-shaped frame and carries a fixed jaw. Also, an arrangement is provided to lock the sliding scale on fixed main scale.

Uses:- Vernier calipers are employed for both internal and external measurement. It is generally used by closing the jaws on the work surface taking the reading from the main as well as the vernier scale.

3. Micrometer:- A micrometer (also called a micrometer screw gauge) is a precision measuring instrument used to measure small dimensions with high accuracy, typically in the range of 0.01 mm (10 microns) or smaller. It operates using a calibrated screw mechanism to measure thickness, diameter or depth.

Types of micrometer:-

- 1) Outside micrometer.
- 2) Inside micrometer.
- 3) screw thread micrometer.
- 4) Depth gauge micrometer.

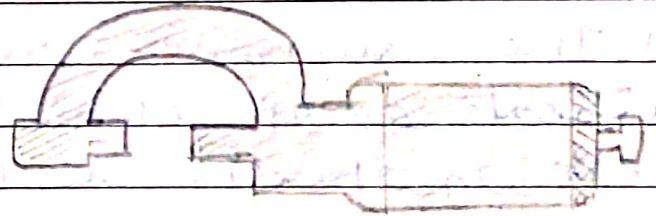


Fig:- Micrometer

Principle of micrometer:- The micrometer works on the principle of a screw and nut mechanism where the rotational movement of a precision threaded screw is converted into linear movement. This allows for very fine and accurate measurements.

How it works:-

- 1) A simple (movable screw) moves forward or backward as the thimble is rotated.

- 2) The spindle moves precisely along a threaded screw which has a known and precise pitch (common 0.5 mm per revolution).
- 3) A ratchet stop or friction thimble ensures uniform pressure to avoid measurement error.
- 4) The movement of the spindle is measured using a scale on the sleeve (main scale) and a rotating scale on the thimble (circular scale).
- 5) By reading both scales a precise measurement is obtained.

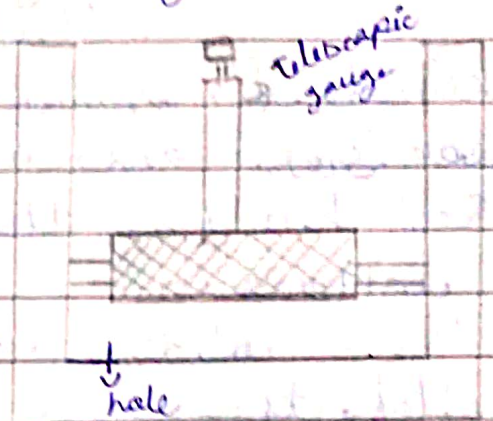
This screw gauge principle allows micrometer to measure very small dimensions with high accuracy.

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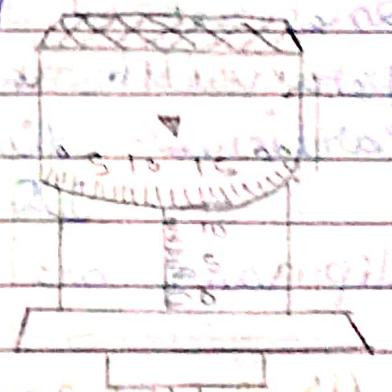
* telescopic gauge:- The telescopic gauge is used for measuring internal diameter of hole, slot, grooves etc. it consists of a handle with a rod in a tube at one end and a working screw at the other end.

The locking screw can lock the rod at any

desire location while taking measuring the read are pressed closer at inserted into the hole when the desired place is which the read are open and the touch the metal surface and are locked. the gauge is then taken out and measurement is obtained by measuring the diameter across the using vernier calliper and micrometer.



* Depth micrometer:- Depth micrometer as the name indicates is used for measuring the depth of holes, slots and recessed areas. 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 in steps of 25 mm may be used for larger range of measurement. The extension rod can easily be inserted by removing the spindle cap. When the cap is replaced, the rod is held firmly against the reference surface.



* Slip gauge (or) gauge block :- These are rectangular blocks of high grade steel with very accurate dimension. These blocks are hardened for wear resistance and cooled for removing stress. After hardening they are finished by high grade lapping.

Sliders of slip gauges are made flat and parallel. This are made from tungsten carbide to insure best result.

Cross section for slip gauges are :-

-> $9\text{ mm} \times 30\text{ mm}$ for size upto 10 mm .

-> $9\text{ mm} \times 35\text{ mm}$ for size above 10 mm .

These dimension are permanently marked on them. One set of slip gauge can have different range but there will be only one slip gauge of one particular dimension.

If one gauge is not sufficient, these slip gauges are used after bringing together.

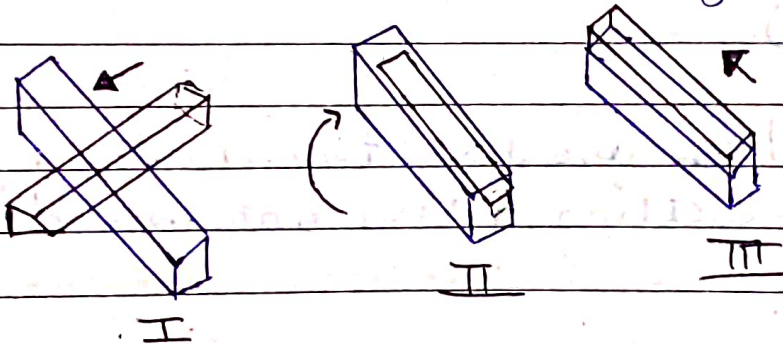
:- Uses of gauge block :-

- 1) In measurement of gaps, slots, groups etc.
- 2) For setting a machine.
- 3) In making gaps between part of the machine.
- 4) For checking the accuracy of other instruments like :- Vernier calliper.

5) It is also used in angle measurement.

* Wringing of slip gauge :- It is the process of combining two slip gauge in such a way that there is almost no gap between them.

Slip gauge are wrung together by hand through a combined sliding and twisting motion. The gap between two wrung slip is 0.635×10^{-3} mm which is accuracy.



:- Procedure of wringing :-

1) before using the slip gauges are cleaned the help of a lint free clothes.

2) one slip gauge is ~~rotated~~ oscillated slightly over the other gauge with a light pressure.

3) gauge is placed so and rotated until the gauges are in one line.

4) the gauge is again slid and they are perfectly combined.

In this way air is expelled out between the

Gauge and due to adhesion both the gauges act as one single gauges.

:- Grade of slip gauges:- There are 4 types of grade:-

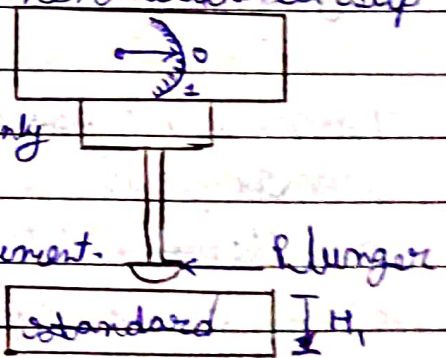
- Grade II :- these are workshop grade gauges. which are used for rough checking. they are used for primary setting of components where less accuracy is required (tolerance range is wide).
- Grade I :- these are used for make precise work such as setting a sine bar or dial test indicators.
- Grade 0 :- These are ⁱⁿ inspection grade used in tool room and inspection department for high accuracy work.
- Grade 00 :- These gauges are used for highest precision work such as checking grade I and grade II slip gauges. These are placed in standard room.

* calibration grade :- It is a special grade which have a special chart with actual size. As slip gauges the chart must be created by making a the dimension.

Range	Steps	No. of 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 Pieces.

* comparator :- It is used Precision instrument used to compare dimension of a given component with a slip gauge.

- > It does not measure the actual dimension, only gives the difference b/w dimensions.
- > It is an indirect type of precision instrument.
- > Application :- In mass production industry inspection.



-> H_1 = Standard Dimension (let say height).

H_2 => Workpiece Dimension (let say height).

$$\Delta H = H_1 - H_2$$

{ variation }

:- Classification :-

- 1) Mechanical
 - > Dial indicator / Dial gauge
 - > Read type Mechanical comparator
 - > Johnson micrometer
 - > Sigma comparator
- 2) Optical
- 3) Mechanical-optical
- 4) Pneumatic
- 5) Electrical
- 6) Electronic

-> Basic Principle:- The general principle of the comparator is to indicate the difference size between the standard and work being measured by means of some feature on the scale with sufficient magnification.

In the dimension less or greater, than the standard, then the difference will be shown on the dial. It only the difference between the actual and ~~Height~~ standard dimension of the workpiece. To check the height of the Job H_2 , with the standard of height H_1 .

-> Need of comparator:-

-> A comparator is used in mass production to inspect the components to close tolerance with a high

degree of precision and speed.

- > Many dimension can be checked in a very short time.
- > Use of line standard such as vernier caliper and micrometer required considerable skill.

Classification:-

1) Mechanical comparator:-

Principle and working:- A mechanical comparator

or employs mechanical means for magnifying the small movement of the measuring stylus, brought about due to the difference between the standard and the actual dimension being checked. In the comparator the magnification of the small stylus movement is obtained by means of levers, gear trains, rack and pinion or a combination. Ratios range from about 250 to 1000.

Mechanical comparators are of the types:-

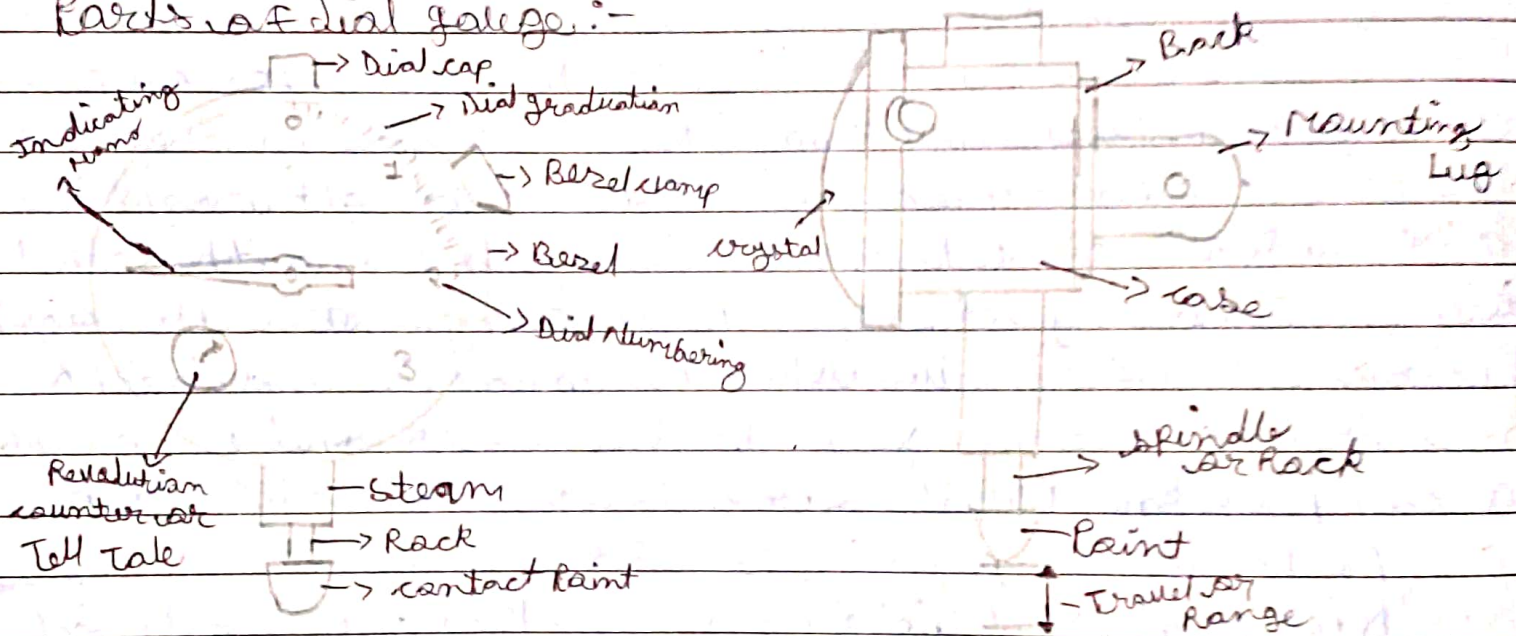
- 1) Dial indicator (Dial gauge)
- 2) Johansson Mikrokator
- 3) Reed type mechanical
- 4) Sigma comparator

1) Dial indicator :-

Introduction:- Dial indicators are small indicating devices using mechanical means such as gears and pinions or lever for magnification system. They are basically used making and checking linear measurement. In fact is a simplest type of mechanical comparator.

The dial indicator measures the displacement of plunger or a stylus. A circular dial means its reading is very sensitive and versatile instrument. Use than other precision instrument, such as micrometer, vernier caliper, gauges etc.

Parts of dial gauge:-



Classification of dial gauge:- according to their shape as (i) sector shaped (ii) circular

Dial sector shape type of instrument ~~the range is~~ the range is very much limited and hence instrument for extreme accurate measurement the circular type dial indicators are more commonly used.

Dial indicator can also be classified as

i) Plunger type

(a) back plunger

(b) plunger parallel to the plane of dial

ii) Lever type.

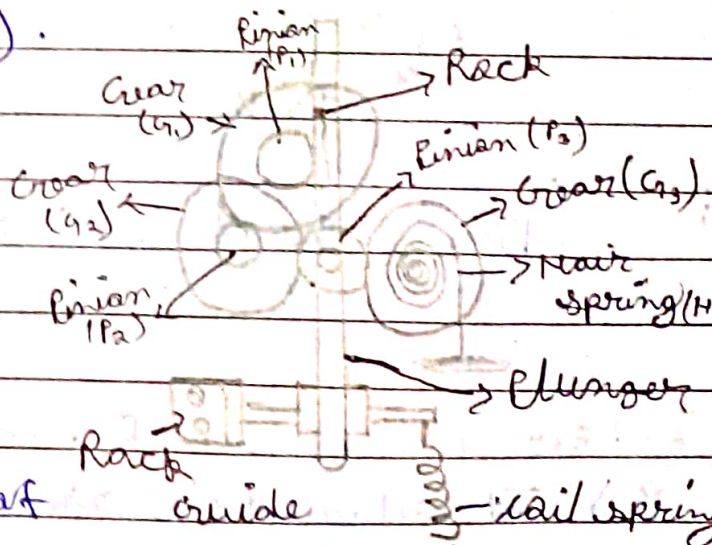
In back plunger type the plunger is at right angles to the dial. It is not widely used.

:- Circular Dial indicator with gear and Pinion :-

The Principle of this gear and Pinion is that the movement of the plunger (spindle) will be multiplied through the series of gear and Pinion and indicated on the main scale on the dial by indicator (Needle).

:- Components :-

- > The plunger will be the one which is moving linearly with respect to the change in on the workpiece while taking measurement.
- > The plunger will consist of a rack and it meshes with Pinion (P_1) on the gear (G_1).
- > circular dial body.
- > Round graduated dial.
- > Pointer.
- > Lever.



:- Working :-

It is indicated on the face of dial by a dial finger. spiral gear train so that hand on dial face indicates the amount of

Movement of the contact point. They are designed use a wide range of standard measuring device such as dial bore gauge, external dial, hand gauges, dial depth gauges, diameter gauges and dial indicator snap gauge. Corresponds to a spindle movement of 1 mm. The large dial scale is graduated into 100 divisions.

Formula:-
$$\text{Least count} = \frac{\pm \text{rotation of main scale (pointer)}}{\text{No. of division on main scale}}$$

$$\text{Least count} = \frac{1 \text{ mm}}{100}$$

$$\pm \text{ resolution of pointer} = 100 \times \frac{1}{100} = 1 \text{ mm}$$

Ex:- 7.50 mm?

$$\text{Soln} \quad \frac{1}{100} < 7.50 \text{ mm} < 10 \text{ mm} \Rightarrow 7 + 0.50$$

$$\begin{array}{c} \text{Main scale Reading} \leftarrow \text{7} + \frac{50}{100} \rightarrow \text{50} \times \frac{1}{100} \rightarrow \text{Least counter} \\ \text{main scale} \end{array}$$

Formula:

$$DGR = RCR + MCR \times LC \quad \text{Unit} = \text{mm}$$

Requirement of Cross Dial Indicator:-

- 1) It should give trouble-free and dependable reading over a long period.

2) It should give

3) The pressure required on measuring head to obtain zero reading must remain constant over the whole range.

3) The pointer should indicate the direction of the movement of the measuring plunger.

4) The accuracy of the reading should be within close limits of the various sizes and ranges.

5) The movement of the measuring plunger should be in either direction without affecting the accuracy.

6) The pointer movement should be damped, so that it will not oscillate when the reading is being taken.

:- Advantages of Dial Indicators:-

1) Dial indicator is most flawless tool in taking linear measurement.

2) The tool is very efficient to assure the quality of a work piece. ~~It is~~

- 3) Due to small tolerances, the size of the dial is very compact and thus it can be used conveniently.
- 4) Dial indicator is also useful in dimension control.

Disadvantage of Dial indicator:-

- 1) The Precision of dial indicator is lost due to the vibration of machinery.
- 2) Space constraints can lead to installing the tool at an angle due to which Precision of the measuring will be lost.
- 3) Another crucial disadvantage of dial is the load - Ark Effect.

Application:-

- 1) Comparing two heights or distances between narrow limits.
- 2) To determine the error in the geometrical form such as parallelity, roundness, and taper.
- 3) For taking accurate measurements of defects.

ation such as intension and compression.

- 4) To determine positional errors of surface such as parallelism, squareness, and alignment.
- 5) To check the alignment of the centers by using a suitable accurate bar between the centers.
- 6) To check the trueeness of milling machine tables and the check the parallelism of shaper arm with table surface or vice.

* Indirect measuring instruments :-

- 1) Telescopic gauge
- 2) small hole gauge

How to use telescopic gauge :-

collapse both measuring heads by rotating the locking screw counterclockwise. Place the gauge into the bore with one head held in place against the wall of the bore.

Begin to loosen the screw, but not by too much because the rods are spring loaded. Proceed to tilt the gauge so the rods are inclined just a touch above horizontal, then tighten the

locking screw. (checkwise) which after 2nd Year
 lifted first, force it downwards the opposite way
 slowly through the bore. As you do this high
 the gauge back and forth. This will allow
 the gauge to find its smallest size on the
 spring.
 Finally, measure with a calibrated
 micrometer.

Q. Build up to this dimension of 57.895 mm with the help of following set of slip gauge?

Sol,

Range	Step	Pieces
1.001 to 1.003	0.001	3
1.01 to 1.03	0.01	3
1.1 to 1.3	0.1	3
1 to 3	1	3
10 to 30	10	3

→ 57.895 mm

Step-1 :- 0.005

which is not available in the this table

∴ 1.005 ---- (i)

required dimension

57.895

- 1.005

56.890

Step-2 :- 56.89 mm

here 0.09

which is not available in the table

∴ 1.09 ---- (ii)

required dimension

56.89

- 1.09

55.80

Step 3 $\rightarrow$ 55.8 mm

here - 0.8

which is not available to this table

$\therefore$ 1.8 --- (iii)

required to dimension

55.8

- 1.8

54.0

Step 4 $\rightarrow$ 54 mm

here - 50 --- (iv)

which is available this table for the number -

54

- 50

4

Step - 5 $\rightarrow$ 4 mm

4 --- (v)

required to the dimension

4

- 4

0

required the using slip gauge that is equal to eqⁿ
all ---

$$= 1.005 + 1.09 + 1.8 + 50 + 4$$

$$[= 57.895 \text{ mm}] \text{ Ans.}$$

Q.2 Build up to the dimension of 46.635 mm help the following set of slip gauge set,

Range	Step	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	9
1.005	-	1

Step 1 $\rightarrow$ 46.635 mm

here $\rightarrow$ 0.005

which is not available in table -

$\therefore$ 1.005 --- (1)

Required the dimension :- 46.635

- 1.005

45.630

Step 2 $\rightarrow$ 45.63 mm

here - 0.03

which is not available in this table

$\therefore$ 1.03

1.03 is available in this table लेकिन आगे Step के लिए इसे change करता हूँ -

1.13 --- (2)

Required the dimension

45.63

1.13

44.50

Step 3 $\rightarrow$ 44.5 mm

here 0.5

0.5 is available in the table लेकिन Step को कम करने के लिए हमें 4.5 लगे

∴ 4.5 $\rightarrow$ (3)

44.5

4.5

40.0

Step 4 $\rightarrow$ 40 mm

here 40

is available in table —

Required diameter —

40

40

00

Required the using slip gauge is step eqⁿ —

$$= 1.005 + 1.13 + 4.5 + 40$$

$$[= 46.635 \text{ mm}] \text{ Ans}$$

Q.3 Bail up to the dimension of 28.75 mm with help to following set of slip gauge.

Sol,

Q.2 के table के Required dimension का देय कर बताइए —

Range	step	Pieces
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 3.5	0.5	19
10 to 30	10	9
1.005	-	1

Step 1 $\rightarrow$ 29.758 mm
0.008

which is not available to the table -

$\therefore$ 1.008 --- ①

Required the dimension :- 29.758

$$\begin{array}{r} 29.758 \\ - 1.008 \\ \hline 28.750 \end{array}$$

Step 2 $\rightarrow$ 28.75 mm
0.05

which is not available to used table -

$\therefore$ 1.05

$\therefore$ dimension ke step ko kam करने के लिए हम जया सकया लेगे -

$\therefore$ 1.25 --- ②

Required dimension 28.75

$$\begin{array}{r} 28.75 \\ - 1.25 \\ \hline 27.50 \end{array}$$

Step - 3 $\rightarrow$ 27.5 mm

Here 7.5 --- (3)

Which is available in the table ---

$$\begin{array}{r} \text{Required dimension} \quad 27.5 \\ \quad \quad \quad \quad \quad 7.5 \\ \hline \quad \quad \quad \quad \quad 20.0 \end{array}$$

Step 4 $\rightarrow$ 20 mm

Which available in table

$\therefore$ 20 --- (4)

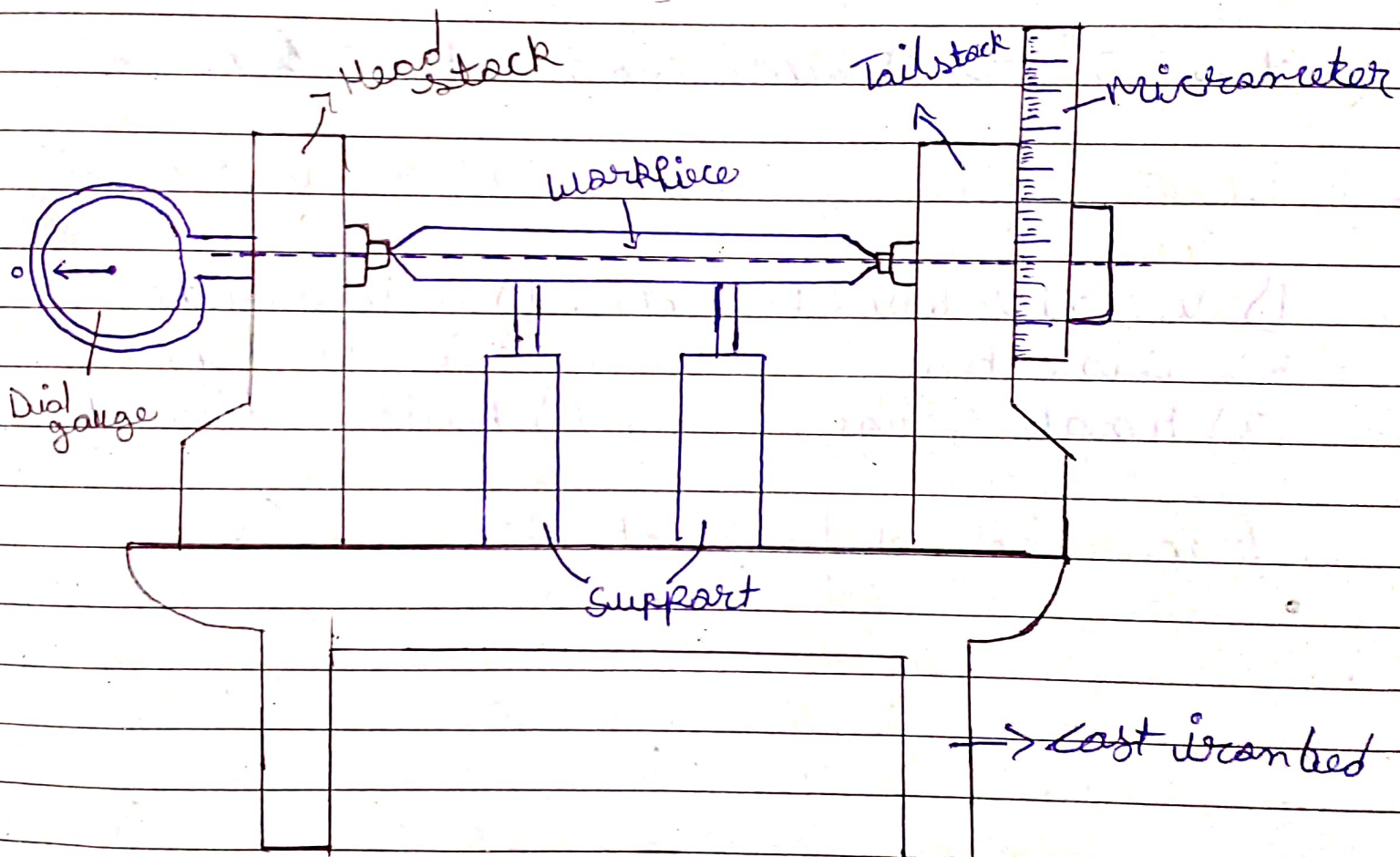
$$\begin{array}{r} \text{Required dimension} \quad 20 \\ \quad \quad \quad \quad \quad - 20 \\ \hline \quad \quad \quad \quad \quad 00 \end{array}$$

$$\begin{aligned} \therefore \text{Required the slip gauge step eqn} & \text{ ---} \\ & = 1.008 + 1.25 + 7.5 + 20 \\ & \left[= 29.758 \text{ mm} \right] \text{ Ans.} \end{aligned}$$

* Measuring Machines:- Measuring machines are used for measuring length of longer parts which can not be measured by vernier calliper & micrometer. It is an end measuring machine consists of following:-

- 1) Cast iron bed.
- 2) Head stock.
- 3) Tail stock.

4) True adjustable support.



second unit complete

2) Sine Bar:- Sine bar is a precision instrument used along with slip gauge for measurement of angle. It is made of high carbon, high chromium corrosion resistant steel.

:- Construction of Sine Bar:- It consists of a steel bar and two rollers. The rollers are accurate and equal diameters. They are attached to the bar at each end. Distance between the axis of the roller is exactly the length of sine bar which is 100 mm or 200 mm or 300 mm.

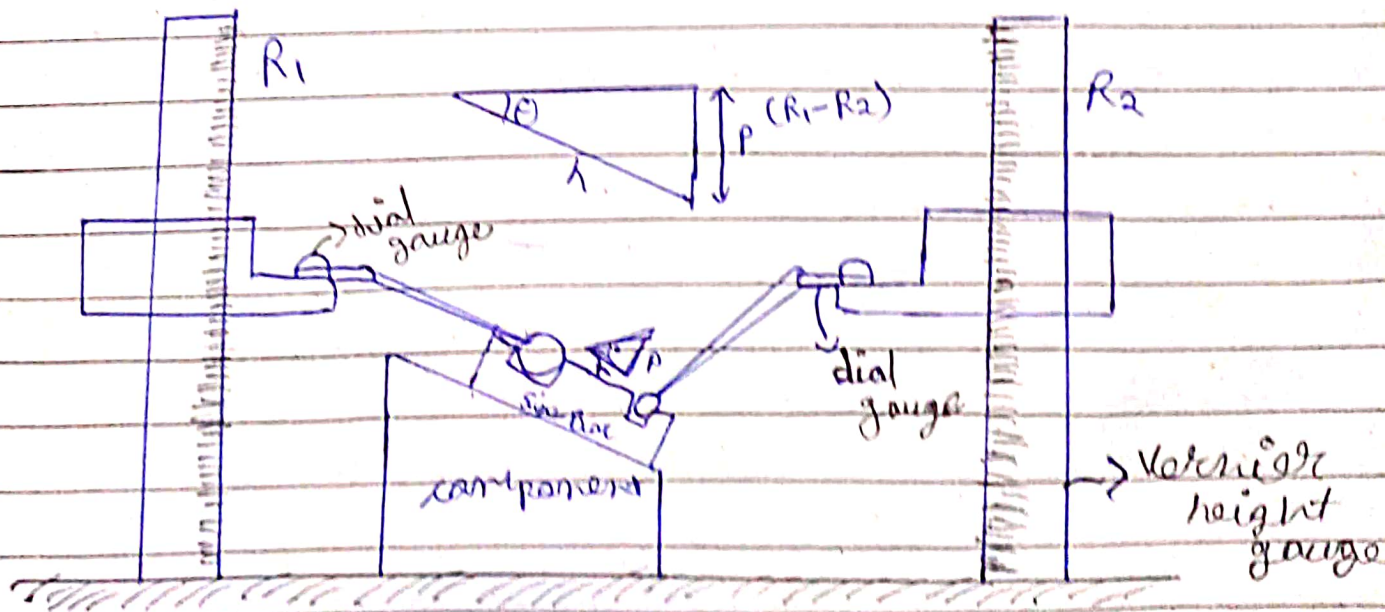
:- Principle and working of sine bar:-

The principle of operation is based on the application of ^{trigonometry} ~~trigonometry~~. The work piece whose angle is to be measured is placed over the upper surface and slip gauges are placed below any one of the rollers.

Slip gauge are inserted until the surface of workpiece is parallel to the base. It is checked by dial gauge by moving over the surface. It is where is no reading when the surface is parallel.

$$\left[\sin \theta = \frac{\text{height of slip gauge}}{\text{length of sine bar}} \right]$$

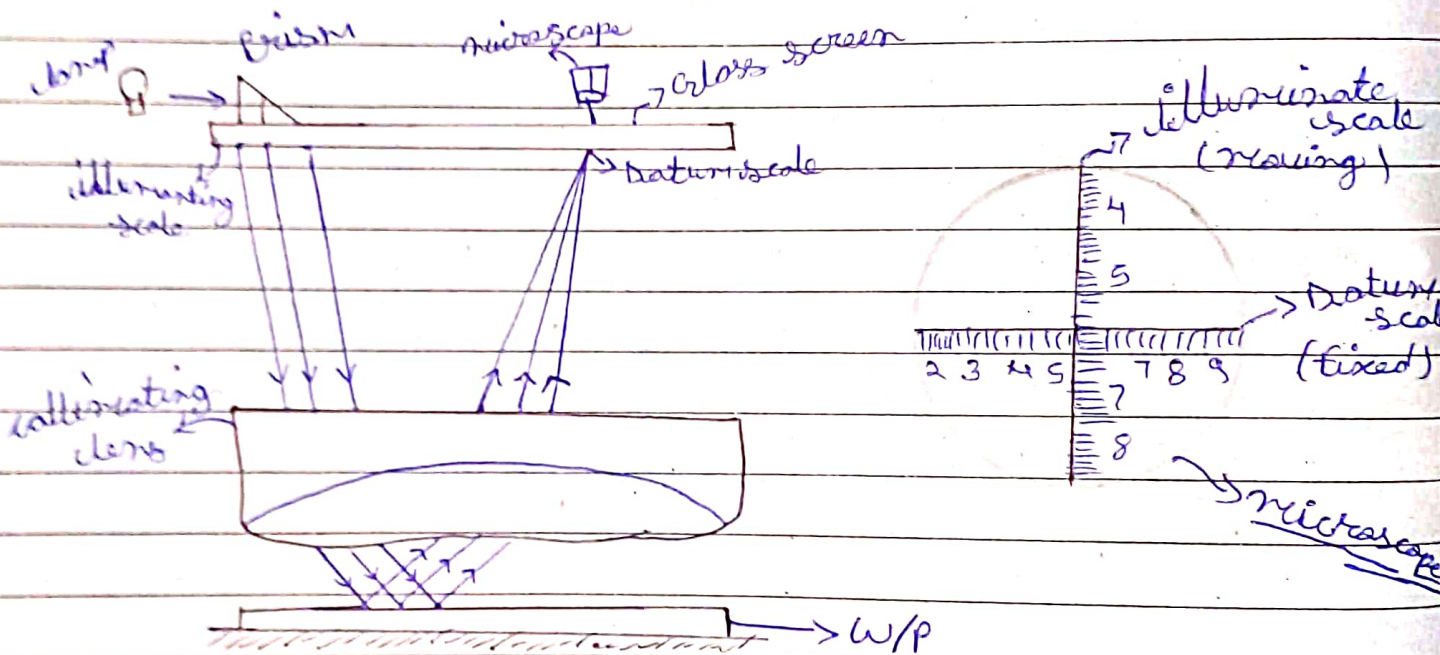
- Uses:-
- 1) Measurement of small angle of small components.
 - 2) Measurement of angle of large component.



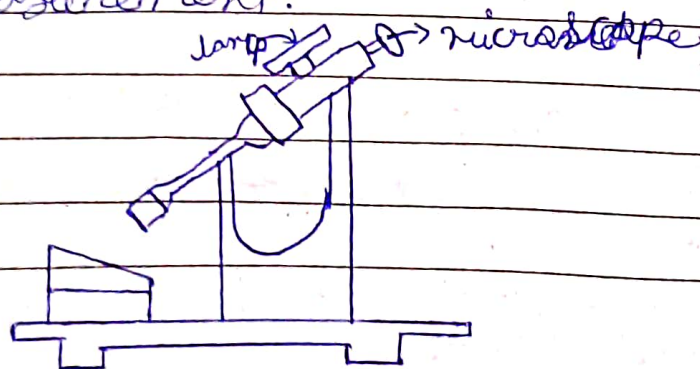
Assignment-2

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Q) Angle Dekkor:- Angle Dekkor is a type of autocollimator which is used to angle measurement with the help of angle gauges and stripe gauges. It is known as Angle dekkor.



* Construction:- It consists of a light lamp, a prism which help in reflecting the light of lamp at 90° to its source collimating lens. A glass screen is there which has illuminating and Datum scale is there ~~where~~ microscope is there to observe for accurate measurement.



google

Working:- The illuminating (vertical) and datum (horizontal) scales, fixed in a glass screen and are mounted in the central plane of the collimating lens. A microscope eyepiece is arranged on a top of the glass screen to observe the measurement carried out on the both the scales the whole setup is arranged in a tube and is mounted on an adjustable table. The beam from the lamp is allowed to fall on the collimating lens. through prism and glass screen the beam strikes the mark piece and then the reflected image falls on the glass screen such that it comes in the view of microscope eyepiece. The ~~the~~ reflected image of illuminating scale falls at right angle of the fixed datum scale thus intersecting the position of two scales with each other. Therefore, the reading measured from the illuminating scale gives the angular deviation from an axis at right angle (90°) to the optical axis and the reading measured from datum scale gives the deviation from an axis mutually perpendicular to either two scale the difference between the two readings on illuminating scales gives an error.

google

Advantage of Angle detector:-

1) It has the ability to measure small angular variations.

- 3) The cost associated with instrument is comparatively less.
- 3) It is capable of measuring angles at short distance.
- 4) The measurement obtained is accurate.
- 5) It is simple in construction.
- 6) It can be used as comparator.

2) Auto collimator: Is an optical instrument used to measure small angular displacement or to check the alignment (collimation) of optical system. It works by projecting light onto a reflective surface, typically a mirror, and measuring the angle of the reflected light. The device can detect minute angular deviation with high precision, making it useful in various applications like optical system calibration, machine alignment, and precision engineering.

Construction: Key Points:

- 1) Light source: A small, bright light source like an LED or laser diode is used to project the light beam. This light is typically collimated into parallel rays to maintain precision.

- 2) Collimating lens:- The collimating lens is used to produce a parallel beam of light, ensuring that the light rays emitted are parallel when they travel towards the object under measurement.
- 3) Reticle or Micrometer scale:- A reticle is typically used to allow the measurement of the angular displacement. In some advanced models, a micrometer scale is used for more precise measurement.
- 4) Beam splitter / Reflector:- A beam splitter or reflector directs the light toward the mirror or surface under measurement. This component can also reflect the light back into the instrument after the object under measurement reflects it.
- 5) Receiving Lens / Detector:- This lens or detector captures the reflected light beam, and any deflection in the reflected beam path is used to determine the angular displacement.
- 6) Eye Piece / Display:- The eyepiece allows the operator to visually observe the reflected image and its alignment.

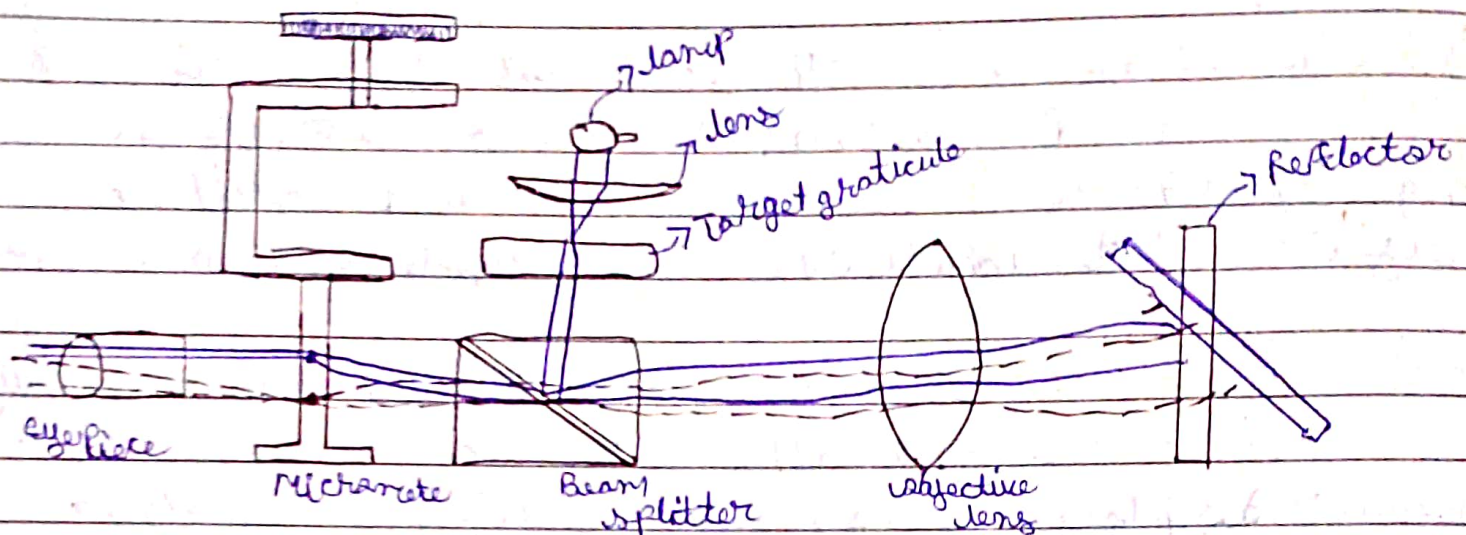


Fig: Auto collimator

Working:- following steps:-

- 1) collimation of light:- The light source emits a beam of parallel rays, which is collimated by the collimating lens.
- 2) reflection from the object:- The parallel light beam is directed towards a reflective surface (usually a mirror or object being measured) if the object is perfectly aligned or flat the reflected beam will return along the same path.
- 3) Measurement of Deviation:- Any tilt or angular displacement of the object will cause the reflected beam to deviate from its original path the amount of deviation is directly proportional to the

angular change ^{of the} object.

4) Detection of Deviation:- The reflected light is captured by the receiving lens. If the beam has deviated, the image of the reflected light will shift, an angular displacement is measured using the scale or digital readout.

5) Displaying the measurement:- The measurement deviation or angle of tilt is displayed on the instrument, allowing for accurate angular measurement.

6) Application:-

- ① Precision Alignment.
- ② Calibration used for angular measuring instrument.
- ③ Optical Engineering for precise angular measurement.
- ④ Surface flatness with high precision.

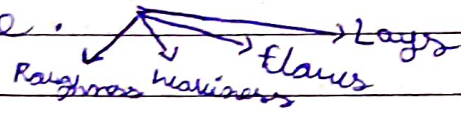
Unit - 4

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Measurement of Surface Roughness

(var) surface characteristic

* Surface texture :- It decrease the nature of the surface.



* Surface irregularity :- It is the decrease from a perfectly smooth surface it can be either microscopic changes or large scale changes.

* Factor affecting surface roughness :-

- 1) Machine and its vibration.
- 2) Workpiece and its material.
- 3) Process
- 4) tool
- 5) type of coolant.

* Orders of geometrical irregularities :-

1) First order :- Due to inaccuracy in machine tool.

Ex :- 1) Lack of straightness of guide ways in which tool move.

2) Deformation of work Due to cutting force.

2) Second Order (Vibration) :- irregularities Due to vibration.

Ex :- chatter marks.

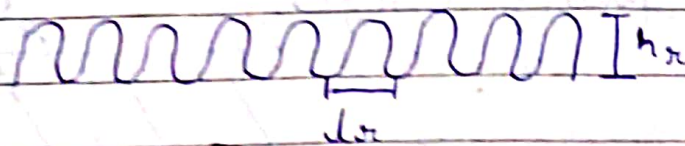
3) Third Order:- Irregularities Due to Process of Machining.

ex:- Feed mark of cutting tool.

4) ~~Fourth~~ Fourth Order:- Irregularities Due to rupture or chip when it separates from work piece.

* Classification of Surface Irregularities (or) texture:-

1) Primary texture (roughness):- In these surface irregularity is as small wave length it is called as surface roughness. In these the ratio length deviation and height deviation is less than 50. It includes third and fourth order irregularity.

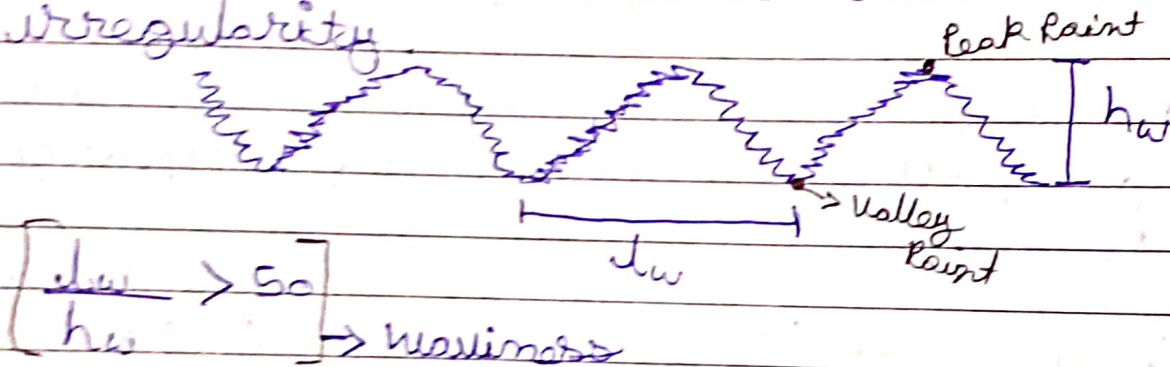


h_r = height of deviation
 l_r = length of deviation

$$\left[\frac{l_r}{h_r} < 50 \right]$$

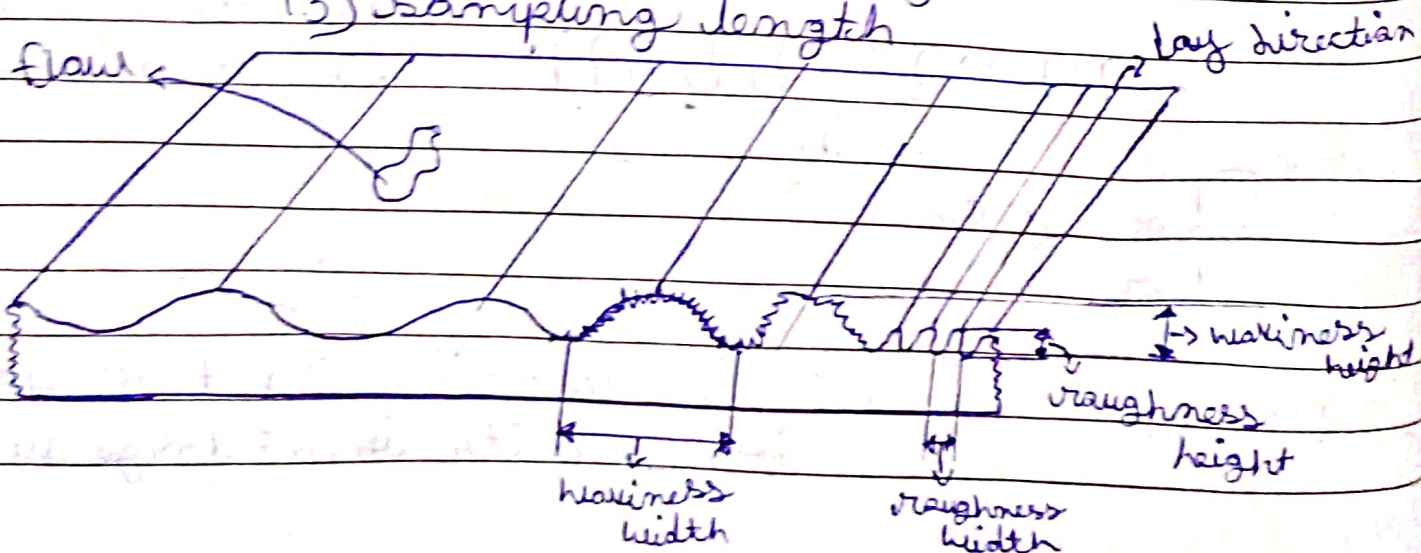
2) Secondary texture (waviness):- In this surface irregularity is as large wave

length it is also called as waviness. because the ratio of l_w and h_w is greater than 50. it includes first and second order irregularity



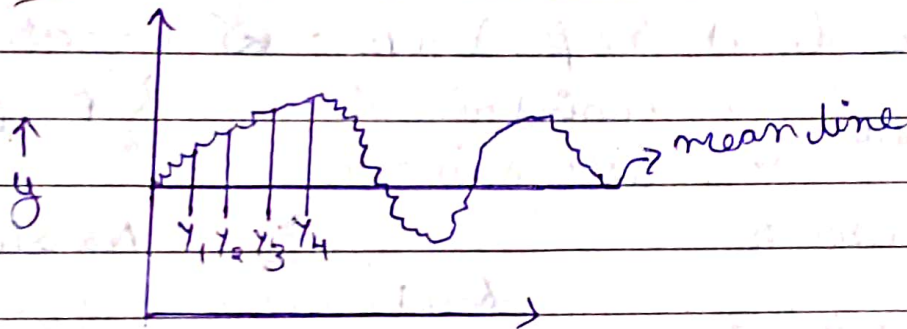
* Element of surface texture :-

- 1) Surface.
- 2) Nominal surface
- 3) Actual surface
- 4) Profile.
- 5) Roughness
- 6) Roughness height
- 7) Roughness width
- 8) Roughness width cutoff
- 9) Waviness
- 10) Flaws.
- 11) Effective profile
- 12) Lay
- 13) Sampling length



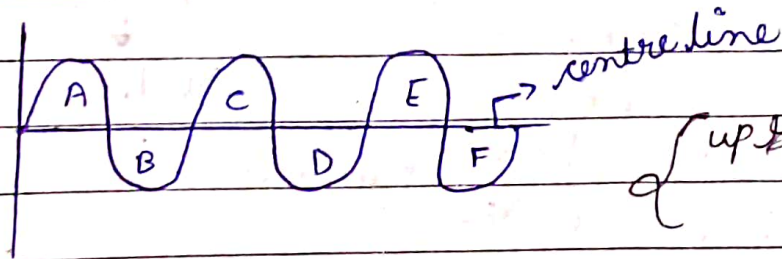
* Profile of surface irregularity :-

1) Mean line profile :-



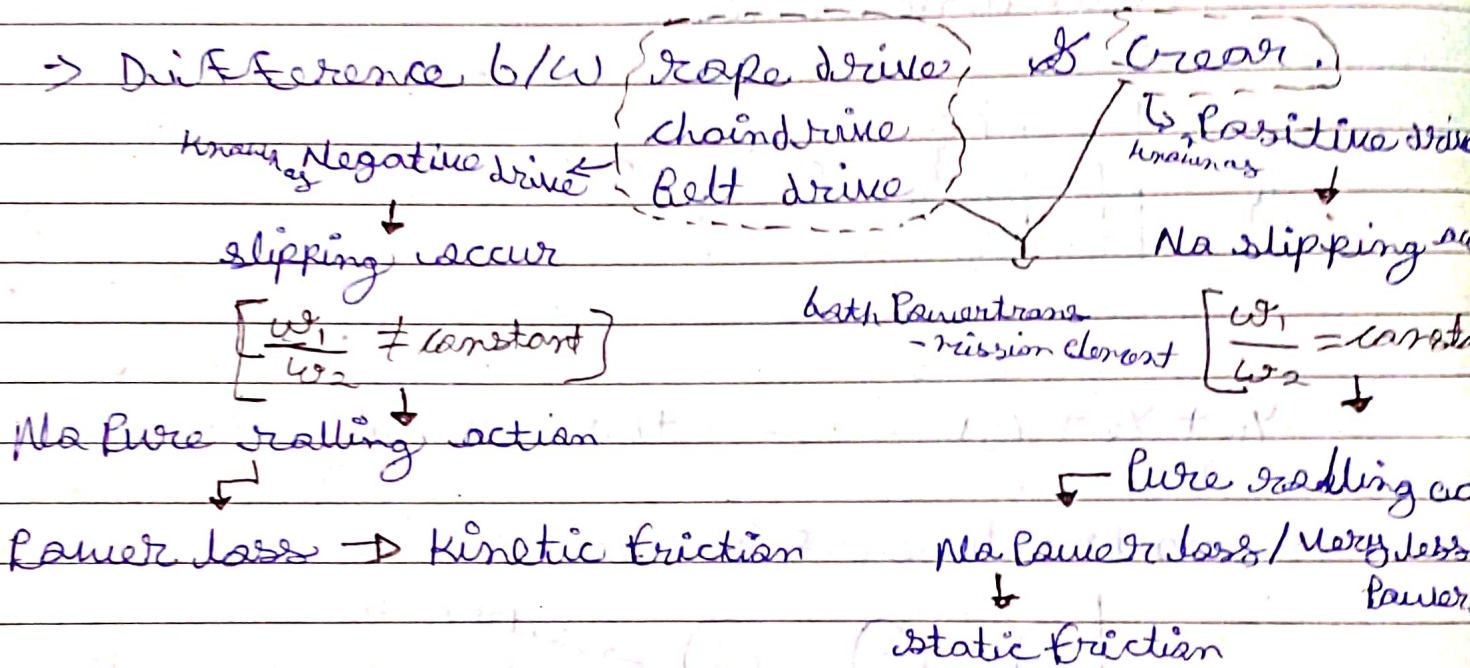
$$y_1^2 + y_2^2 + y_3^2 + \dots + M.L = \text{minimum}$$

2) centre line of profile :-



Unit-5.2

* Creep :- It is a power transmission element.



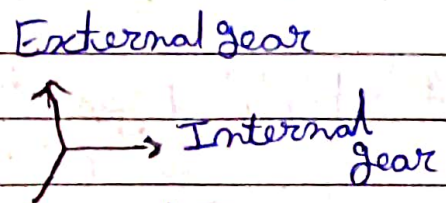
① Slipping occur :- $\left[\frac{\omega_1}{\omega_2} \neq \text{constant} \right]$

- $\rightarrow$ No Pure rolling action.
- $\rightarrow$ Power loss.
- $\rightarrow$ Kinetic friction.

② No slipping occur :- $\left[\frac{\omega_1}{\omega_2} = \text{constant} \right]$

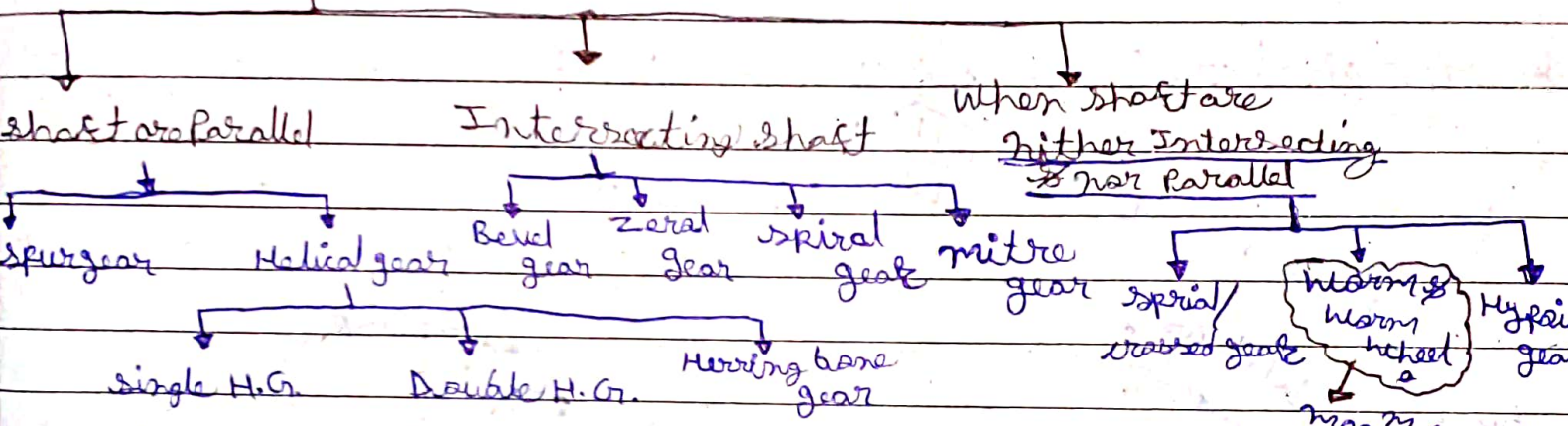
- $\rightarrow$ Pure rolling action
- $\rightarrow$ No Power loss / Very less Power loss
- $\rightarrow$ Static friction.

:- classification of gears :-



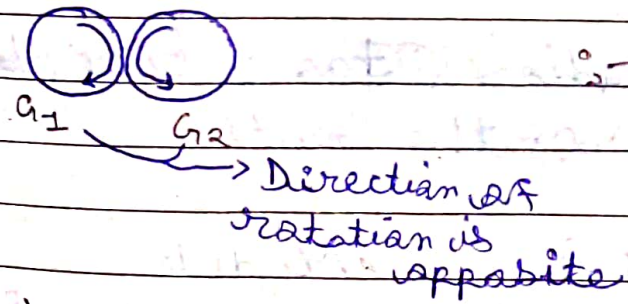
On the basis of axes of the shaft connected.

On the basis of Meshing of gears.

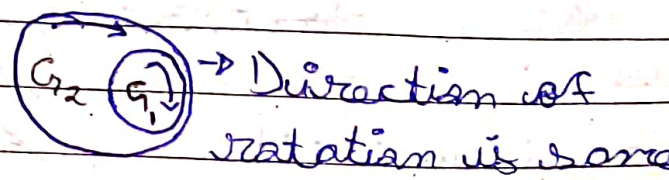


:- Worm & Worm wheel :-
Maximum speed reduction ratio upto 1250:1

:- External gear :-

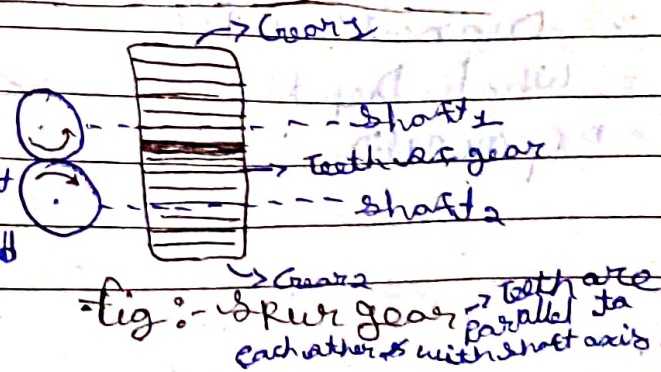


:- Internal gear :-



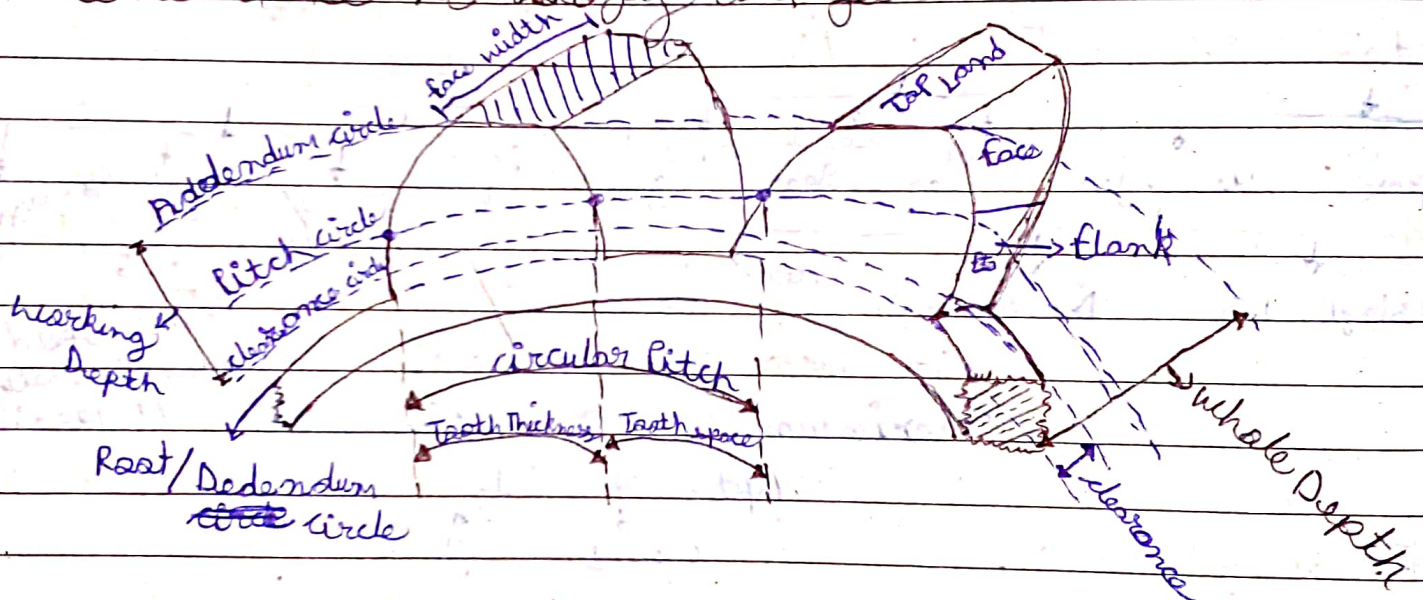
1) Spur gear :- :- teeth are parallel to each other.

- > instantaneous engagement & disengagement
- > Vibrations -> impact stress -> high speed reduction is not achievable.
- Use in low power transmission or low S.R. Ratio



- ② Helical gear:- ① Teeth are inclined to the shaft.
 ② Instantaneous engagement ③ Point contact
 ③ Vibration & Impact stress eliminate (नहीं होता).
 ④ high power transmission possible.

* General terminology of gears:-



* ~~Addendum~~: ~~It is the radial distance b/w the pitch circle & top of the tooth.~~

* Gear terminology:-

- | | | |
|-------------------|--------------------|--------------------------------|
| → circular pitch | → Pitch circle | → Module |
| → Diametral pitch | → Addendum - P_a | → Dedendum - P_d |
| → Whole Depth | → Working Depth | → Backlash Backlash |
| → Gear Ratio | → Pressure Angle | |

* **Addendum**:- It is the radial distance between the Pitch circle and top of the tooth.

* **Dedendum**:- It is the radial distance between the Pitch circle and Bottom of the tooth.

* **Whole Depth**:- Total height of the tooth, equal to ~~sum~~ of Addendum and Dedendum.
-m.

* **Pitch circle**:- It is an imaginary circle in the gear where pure rolling motion is observed when the mating gears are transmitting power.
⇒ Being an imaginary circle it cannot be the physical characteristic of the gear but still it is the most important specification of the gear. because size of the gear is specified by the Pitch circle diameter.

* **Circular Pitch**:- Circular Pitch is the distance between the corresponding point of the adjacent teeth measured at the Pitch circle. In other words It is the space between the teeth. In order to have proper Meshing / Mating of two gears the

~~pitch circle dia~~

Must have to be same.

(mm)

$$\text{root int. } \left[P_c = \frac{\pi D}{T} \right] \text{ where, } D = \text{Pitch circle Dia.} \\ T = \text{Teeth}$$

:- Module :- It is major ~~of~~ measure of gear size defined as Pitch circle diameter divided by Number of teeth.

$$T = \text{No. of teeth.} \quad \left[m = \frac{D}{T} \right] \text{ where, } D = \text{Pitch circle diameter} \\ \text{✓ (mm)}$$

relation between ~~pitch~~ circular Pitch and module

$$\left[P_c = \pi m \right]$$

For ~~two~~ ^{two} gear Mesh properly they must have same module.

:- Working Depth :- For single gear addendum + Dedendum - clearance.

→ For two mating gears the working Depth is equal to sum of Addendums of the two mating gears.

:- Backlash :- To avoid the Jamming or static due to thermal expansion some include in tooth space is provided to the mating gear and

this is known as Backlash.

:- Pressure angle :- Pressure angle is the angle between the line of action and common tangent at the Pitch Point is known as Pressure angle.

:- Gear ratio :- Gear ratio is the ratio of number of teeth in number of pinion.

$$\left[\frac{C_r}{T_g} = \frac{T_p}{T_g} \right] \text{ formula.}$$

Prf ma 6, it is determined by

* Measurement of gear clearance :-

:- Measurement of pitch :- Pitch is the distance between corresponding points on equally spaced & adjacent teeth.

Pitch error is the difference in distance b/w equally spaced adjacent teeth & measured distance b/w any two adjacent teeth.

The types of pitch measuring instrument :-

1) Pitch measuring instrument :- They enable the measurement of chordal pitch b/w successive pairs of teeth.

→ The instrument consists of one fixed finger & one movable finger.

→ These fingers are set to two identical limits on adjacent teeth along the pitch ~~circle~~ circle.

→ The pitch variations are indicated on the dial indicator which is attached to the instrument.

→ The limitation of this method is the reading are influenced by profile variation & run out of teeth.

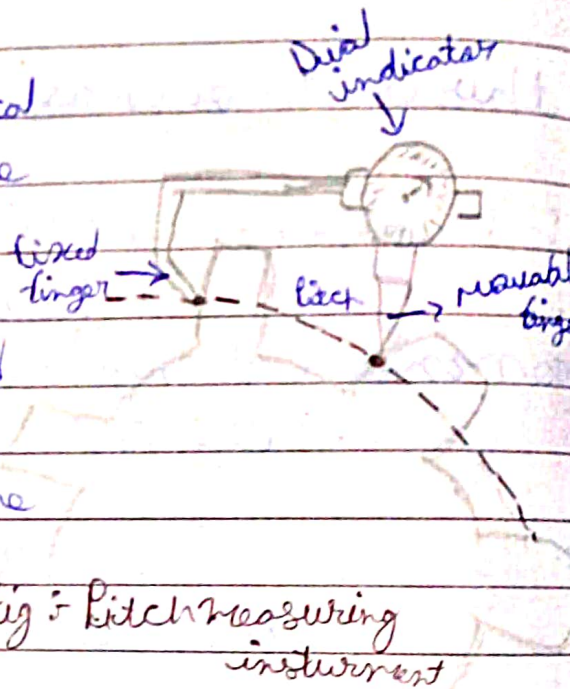


Fig: Pitch measuring instrument

2) Pitch checking instrument:- It is an instrument that as a dividing head can be used to measure pitch variation.

→ can be used for small & large gears as it is portable. It has two probes → one fixed or anvil.

→ other movable called as measuring feeler. measuring feeler is connected to dial indicator through levers.

→ The instrument is held in position by two adjacent supports resting on the crests of the teeth.

→ Tooth flank is butted against the fixed anvil & locating supports.

→ The measuring feeler sense the corresponding next flank.

→ It is used as comparator & we can measure addendum pitch, actual pitch, accumulated pitch error.

* Measurement By Parkinson gear tester :-

→ Parkinson gear machine is generally used for comparison gear inspection.

→ composite action refers to the variation in center distance when a gear is rolled in tight mesh with a standard gear.

→ This machine can reflect gear idleness, tooth to tooth spacing & profile variation.

→ It is a popular gear testing machine used in metallurgy laboratories & tool rooms.

→ The gear being inspected will be made to mesh with a standard gear, and a dial indicator is used to capture radial errors.

:- Parts of the machine :-

* Table * Base * Scale

* Dial indicator * Sliding carriage * Master gear

→ standard gear is mounted on a fixed frame.

→ gear being inspected is fixed on a sliding frame (carrier).

→ The two gears are mounted on Mandrels, which facilitate

so accurate measuring of gear on machine & help the dial indicator to linearly measuring irregularities in the gear under inspection.

- Date:

- :- Working :-** The two gears mounted on mandrels & the slide of standard gear is fixed at a centred position. The sliding carriage is moved along the table the two gears are brought into mesh & the sliding carriage is also lased in its position.
- The sliding carriage is forced to sliding for a small distance on steel rollers under light spring force.
 - A vernier scale attached to the machine enables measurement of the centre distance upto 25 mm.
 - The dial indicator is set to zero & the gear under inspection is rotated.
 - Radial variations of the gear being inspected are indicated by the dial indicator.
 - This variation is plotted on a chart or graph sheet, which indicates the radial variation in the gear for one complete rotation.

* Special measuring instrument :-

- **Total Contact Microscope :-** Microscope is an important metrological tool to provide high degree of magnification & providing simple & convenient means for taking readings.

→ It enables both absolute & comparative measurement.
 :- Principle of microscope: This stage of magnification.

- The objective lens first forms the image of the specimen at I_1 at the stop.
- The stop focuses the image so that it can be enlarged by the eyepiece.
- When we see through the eyepiece, an enlarged virtual image I_2 is obtained.
- The main use of a dual marker microscope is to measure the shape, size, angle & position of small component that fall under microscope measuring stage.

:- construction: ~~There is a~~ There is a vertical column that carries the weight of all other parts of the microscope. The workpiece is mounted on a x-y stage which has a ball in for translatory motion in two principle direction in the horizontal plane.

- Micrometer are provided for both x & y axes to facilitate accurate linear measurement.
- The entire optical system is housed in the measuring head. Measuring head can be locked in position by using the clamping screw.

→ Angle dial built in eyepiece position allows easy angle measurement.

→ Surface illuminator provided the required illumination of the object to give sharp & clear image.

→ Modern microscope have cross ~~hairs~~ wires etched on glass.

eg:- For linear measurement:-

A measuring point on the workpiece is aligned with one of the cross wires & reading R_1 is taken from the microscope.

→ The difference b/w the two readings will give this dimension b/w the two measuring points.

→ Position of workpiece on the table is very important to get accurate measurements.

→ The position of eyepiece mount must be adjusted so that the horizontal cross wire is co-incident with the direction of take measurement.

→ Eye-piece is secured by tightening the fixing screws.

→ Work piece is placed on the table & micrometer head is turned to align an edge of the workpiece with the centre of cross wire.

* Application :-

- 1) Used in shop floor measurements of screw threads, gears & other small machine parts.
- 2) Measurement of test tool in tool rooms.
- 3) It determines the dimension of holes.
- 4) It facilitates template matching inspection.
- 5) It enables inspection of tapes on small component up to an accuracy of 6".

Sr. No.	element	Instrument
1	Teeth thickness	Gear tooth Vernier caliper
2	Gear tooth Inscribed Profile	David Brown Gear tangent micrometer.
3	Circular Pitch	David Brown gear tangent micrometer.
4	Eccentricity	Standard ball and dial gauge.
5	Teeth form Pitch	Parkinson gear tester

* Gear tooth vernier caliper :- Most commonly used & accurate method for measuring the gear 'Teeth thickness' is the measurement by gear tooth caliper. construction details of the gear calliper :- Two scales one is horizontal the other is the Vertical scale.

→ Vertical scale gives position of the blade which can slide up & down. When the surface of the blade is flushed with the tips of the measuring anvils the reading on the vertical scale

will be zero. Blade position can be set to any required value by referring to the Vernier scale.

→ Tooth thickness should be measured at the pitch circle.

→ The two anvils are brought in close contact with the gear.

→ The chordal thickness is noted down on the horizontal scale. Since the gear tooth thickness varies from the tip to the base circle of the tooth.

→ The vertical scale is used to set the depth (s) along the pitch circle from the top surface of the tooth at which the width (w) has to be measured considering one gear tooth the theoretical values of w & s can be found out & verified by the instrument.

From w is a chord ADB , tooth thickness is specified by arc distance AEB . The depth s is slightly larger than the addendum CE , width ' w ' is called as chordal thickness & ' s ' is called chordal addendum.

$$T = 30; m = 5 \text{ mm}$$

$$W = AB = 2AD$$

$$\therefore \left[\theta = \frac{360}{4T} \right]$$

In $\triangle ADO$:-

$$W = 2AD = 2 \times AO \sin \theta \\ = 2R \sin \frac{360}{4T}$$

R = Pitch circle radius

Module or $\frac{D}{T} = \frac{2R}{T}$ (or) $R = \frac{MT}{2}$

$$W = 2 \times \frac{\pi T}{2} \sin\left(\frac{360}{4T}\right)$$

$$W = \pi T \sin\left(\frac{90}{T}\right)$$

$$W = 5 \times 30 \times \sin\left(\frac{90}{30}\right)$$

$$[W = 7.850 \text{ mm}] \text{ Ans.}$$

$\therefore$ Addendum = I read it (by default)

$$OC = OE + \text{Addendum}$$

$$= R + a$$

$$OC = \frac{\pi T}{2} + \pi$$

$$\cancel{OD} = R \cos \theta = R \cos\left(\frac{90}{T}\right) = \frac{\pi T}{2} \cos\left(\frac{90}{T}\right)$$

$$\text{Addendum, } d = OC - OD$$

$$= \frac{\pi T}{2} + \pi - \frac{\pi T}{2} \cos\left(\frac{90}{T}\right)$$

$$\text{Addendum, } d = \frac{\pi T}{2} \left[1 - \cos\left(\frac{90}{T}\right) + \frac{2}{T} \right]$$

$$d = \frac{5 \times 30}{2} \left[1 - \cos\left(\frac{90}{30}\right) + \frac{2}{30} \right]$$

$$[d = 5.1027 \text{ mm}] \text{ Ans.}$$

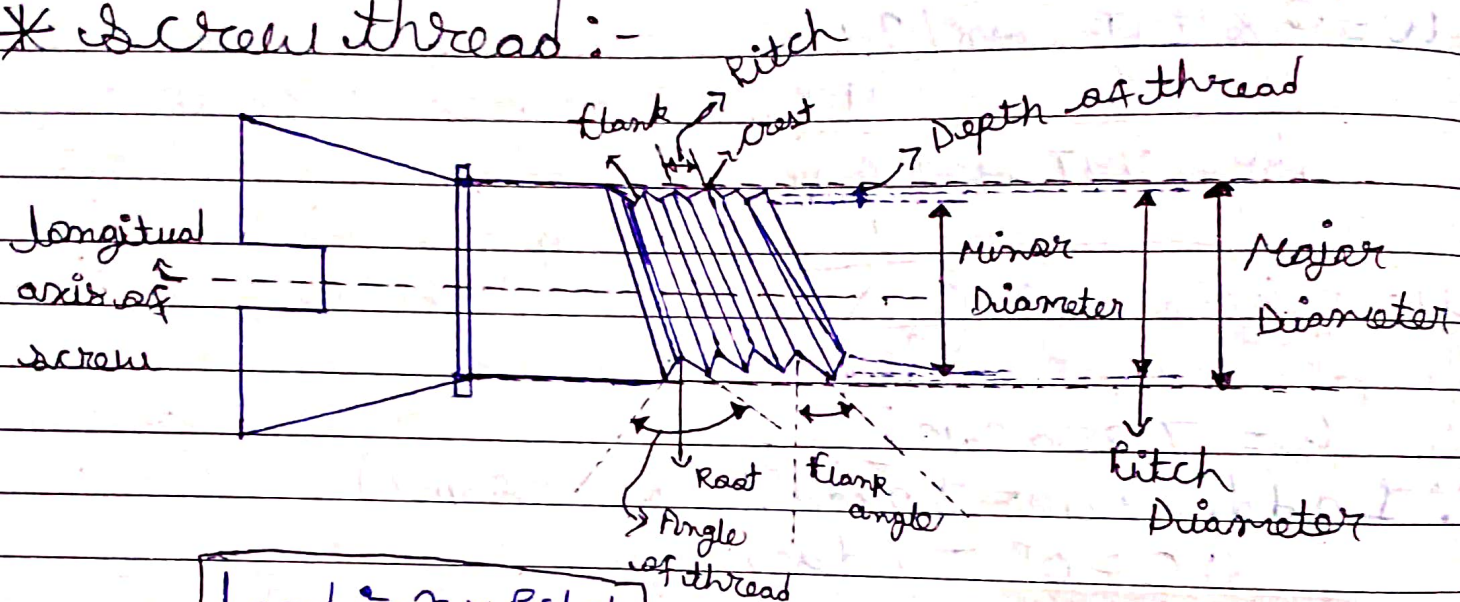
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Unit - 5.1

* Screw thread :-



$$\text{Lead} = n \times \text{Pitch}$$

$$(\text{No. of start} = n)$$

* **Lead** :- The distance covered in the axial direction by rotating the screw inside the nut, on complete revolution is called lead of thread. $\text{Lead} = n \times \text{Pitch}$ here (n) = number of starts, Here starts mean how many equally spaced helical grooves are formed on the surface. If the number of starts is 2 then two threads are cut together at equal distance.

* **Thread Angle** :- The inclination of the flanks of the thread in the axial plane is called "angle of the thread" or "included angle".

- * Flank angle :- The angle made by the normal to the axis of the thread and the flank is the flank angle of the thread and the second value is half of the angle of the thread.
- * Lead angle :- The angle made by the helix of thread on the pitch line with the plane perpendicular to the axis is the lead angle of the thread.
- * Depth of thread :- The distance measured between the crest and root in the direction perpendicular to the axis of the thread is called depth of thread.
- * Helix angle :- The angle made by the helix of the thread with the axis of the thread on the pitch line is the Helix angle of the thread.
- * Minor Diameter :- The diameter of the imaginary cylinder (co-axial) made touching the root of the thread is called the minor diameter of the thread. It is also called "core diameter" or "root diameter".
- * Major Diameter :- The diameter of the co-axial/imaginary cylinder made touching the crest (outer thread) of the thread (and the root of inner type).

thread) is called the major diameter or thread.
It is also known as external diameter, full diameter.

* Effective diameter or Pitch Diameter is

Effective diameter is the diameter of a cylindrical imaginary cylinder which intersects the flank of the thread in such a way that the thickness of the metal of the thread and the space between the thread remains equal. Both are equal to half the pitch.

Penkush user,

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Waviness
roughness { Global phenomena

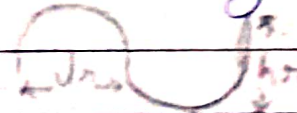
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* Waviness :- Large wavelength Deviation of surface is called waviness. or a surface is said to be off waviness characteristic when the Deviation b/w Peak and Valley is very high.

Waviness appears due to error in guideways (leads screw), Machine vibration, chattering of tools.

Imp. $\left[\frac{L_{wv}}{h_{wv}} > 50 \right]$ - waviness



* Roughness :- Small wavelength Deviation of surface are called roughness. or when the Deviations b/w hill and valley is very small then it is said that the surface is rough. Roughness in the surface appears due to improper selection of cutting parameter that leads to unexpected increase in temperature of machining ~~area~~ areas.

Imp. $\left[\frac{L_{wr}}{h_{wr}} < 50 \right]$ - roughness



:- Process capability :- F, d, v

$F \Rightarrow$ feed

$d \Rightarrow$ Depth of cut

$v \Rightarrow$ cutting velocity

* Flaws:- It is highly localised phenomenon and it appears due to Jerk (जerk).

* Lay:- It is predominant surface pattern produced by the feed marks.

:- Types of Lay:-

1)



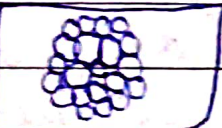
→ Parallel lay ⇒ shaper & lathe (11)

2)



→ Perpendicular lay (⊥)

3)



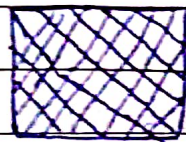
→ Multidirectional lay (grinding) (M)

4)



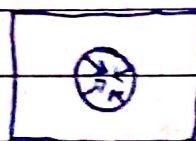
→ Circular lay (C)

5)



→ Crossed lay (X) ⇒ Knurling operation

6)



→ Radial lay (R) ⇒ Slotting

* ~~Surface~~

* Surface characteristic measurement:-

* M-System (Meanline system) :- after plotting the surface characteristics one surface line is drawn by joining the first and last point. This line is then shifted in the upwards and downwards direction. In such a way the ~~section~~ area above the line ~~that area~~ and below the line is same this line is ~~and this~~ called mean line.

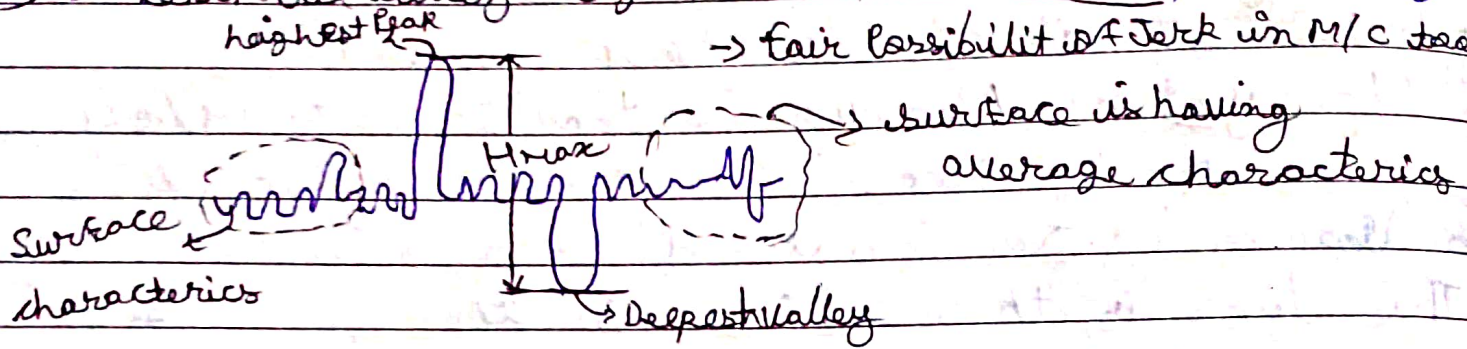
* E-System (Envelope system) :- After plotting the surface characteristics a 25mm diameter sphere is rolled over the surface and locus of the centre is being traced called Envelop. This Envelop is ~~touching~~ closer to a point where area above the Envelop and below the Envelop are same, It is called Mean Envelop.

$\phi = 25\text{mm}$ (2)

* Methods to Quantify Surface Roughness:-

- Peak and Valley height method & H_{max} , R_t , R_{max} .
- CLA Method (centre line average Method) & R_a .
- RMS Method (Root mean square method) & R_q .
- 10 Point value method & R_z .

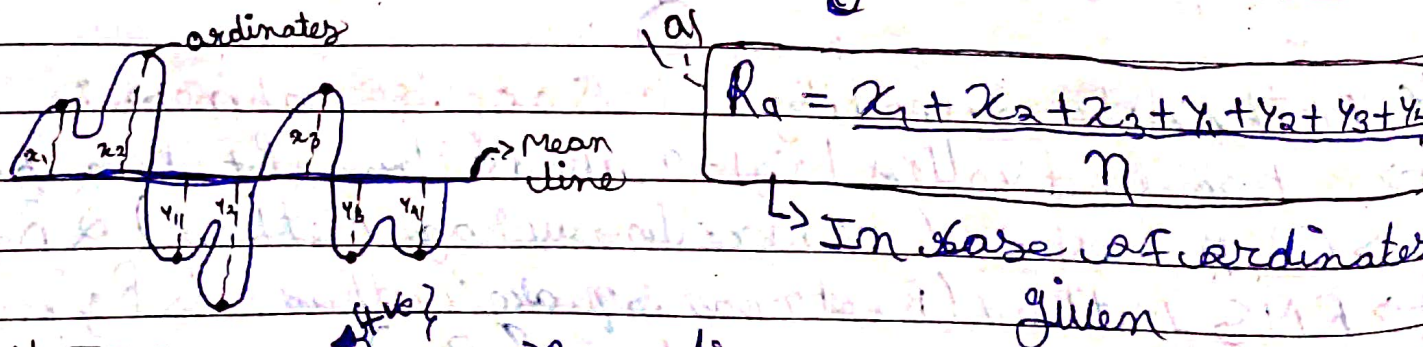
1) :- Peak to valley height method (H_{max} , R_t , R_{max}):



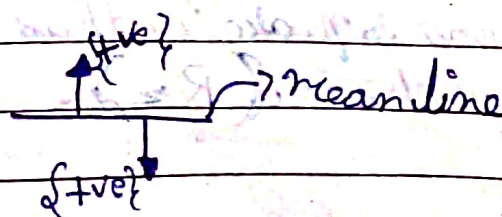
It is the difference b/w highest peak and deepest valley, but some times it doesn't represent surface characteristics properly because this method simply tells the maxi^m deviation value of any surface only and according to which we can't judge the overall surface characteristics.

2) :- CLA & centre line Average method (R_a):-

It is defined as the average height for a meanline of all ordinates of the surface regardless of sign.



★ NOTE :-



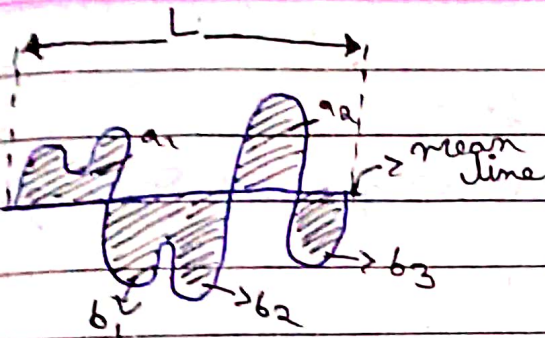
$\left\{ \begin{array}{l} |u| = 10^{-6} \text{ m} \\ |u| = 10^{-3} \text{ mm} \end{array} \right\}$
 u = microns

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$L = \text{Cut-off length} / \text{sampling length}$

$a_1, a_2 = \text{area above mean line}$

$b_1, b_2, b_3 = \text{area below mean line}$



(b) $R_a = \frac{\sum \text{Area}}{L}$ $\rightarrow$ Regardless of sign.
 $\rightarrow$ cycle interpolation
 $\rightarrow$ Cut-off length
 $\rightarrow$ In case of Area given

(c) Approx value $\left\{ R_a \approx \frac{H_{max}}{4} \right\}$

$\rightarrow$ No area, No ordinates given.

$\therefore$ Magnification of factor:-

Horizontal m.f. $\rightarrow$ Vertical m.f.

eqⁿ (a), (b) :- Basic Principle

eqⁿ (c) :- Not used when :- (i) No. of valley & Peak are given
 (ii) Geometrical relation are given

(i) $\left\{ R_a = \frac{H_{max}}{4} \right\}$ $\rightarrow$ You have to use basic principle.
 X X X nhi karunahi

3) :- RMS & Root Mean Square Method (R_g) :-

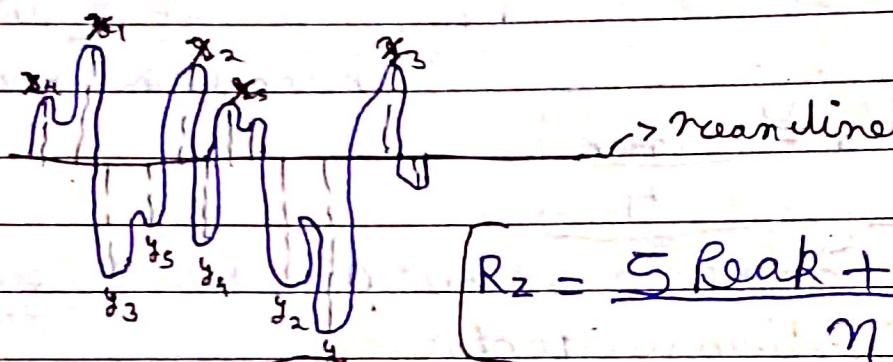
~~R_g~~ It is a parameter that measures the average deviation of the surface from its ideal or meanline or plane. It is calculated by taking the square root of the average of the square of the deviation of the surface profile from the mean.

$$R_g = \sqrt{\frac{y_1^2 + y_2^2 + y_3^2 + \dots + y_n^2}{n}}$$

(or) $R_g \approx 1.1 R_a$
 $R_a = \text{CLA (centre line area)}$

4):- 10 Point value method (R_z) :-

It is the average of 5 highest peak and 5 deepest valley.



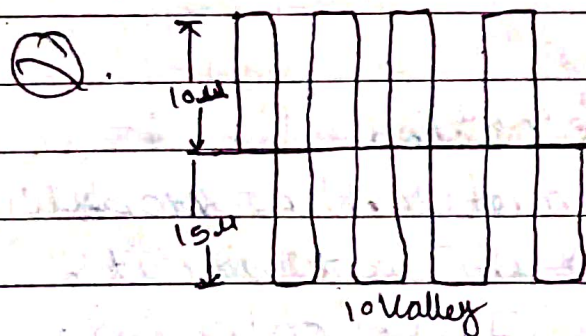
$$R_z = \frac{5 \text{ Peak} + 5 \text{ valley}}{10}$$

$$R_z = \frac{x_1 + x_2 + x_3 + x_4 + x_5 + y_1 + y_2 + y_3 + y_4 + y_5}{10}$$

Relation between surface roughness :-

Peak to valley height $H_{max} > R_z > R_g > R_a > CLA$

10 Peak 10 Point RMS highest accurate



$H_{max} = 9$ Sol,
 $R_a / CLA = 9$

$H_{max} = 10\mu + 15\mu$

$H_{max} = 25\mu$ (RMS)

$R_a = \frac{\sum a + \sum b}{L} \Rightarrow \frac{10 \times (10 \times 1) + 15 \times (10 \times 1)}{20}$

$\frac{250}{20}$

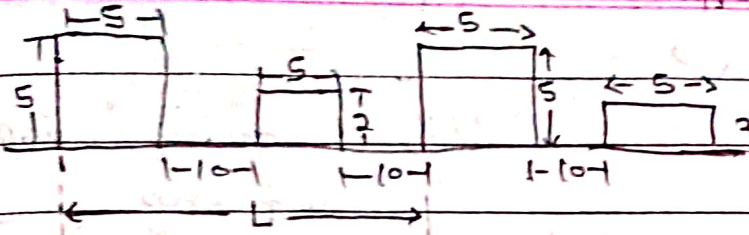
$R_a \approx 12.5\mu$

cycle repetition
than it is not
given

All unit in microns,

$$R_a = 9$$

Q

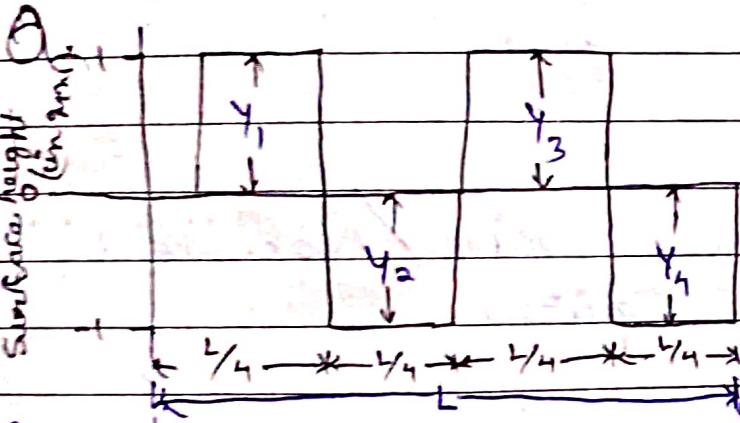


Sol,

$$R_a = \frac{\sum a}{L} \Rightarrow \frac{(5 \times 5) + (5 \times 2)}{5 + 10 + 5 + 10} = \frac{25 + 10}{30}$$

not correct answer
25+10
30 $\Rightarrow 8.33$

$$\frac{25 + 10}{30} \Rightarrow \frac{35}{30} \Rightarrow [R_a = 1.166 \mu m]$$



The centre line average roughness
(R_a in μm) of the measured
length (L) is _____?

Sol,

$$CLA(R_a) = \frac{\sum a + \sum b}{L} \Rightarrow \frac{(1 \times 1/4) + (1 \times 1/4) + (1/4 \times 1) + (1 \times 1/4)}{L}$$

$$\frac{1}{L} \Rightarrow [CLA(R_a) = 1 \mu m] \text{ Ans.}$$

Q. assume that the surface roughness profile
is triangular as shown schematically (as shown in fig)
if the peak to valley height is 20 μm the centre line average
(R_a) in micrometer is :-

Sol,

$$H_{max} = 20 \mu m$$

No. of peak & No. of valley is
not given

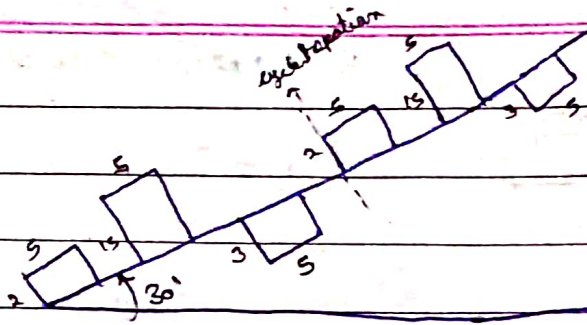
Meanline data is also not given



$$R_a = \frac{H_{max}}{L} \Rightarrow \frac{20}{4} \Rightarrow [R_a = 5 \mu m] \text{ Ans.}$$

6/5/25

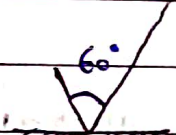
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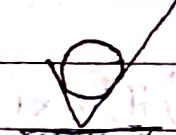
Roughness is independent of angle

Not calculate the angle $\sin \theta / \cos \theta / \tan \theta / \sec \theta / \csc \theta$

* Surface roughness Designation / symbol :-

1)  $\Rightarrow$ Machining optional.

2)  $\Rightarrow$ Surface finish required / Machine finish required.

3)  $\Rightarrow$ Removal of material is not permitted.

4)  $\Rightarrow$ Special surface features required.

* Special surface features :-

* Production Method

* cut off length

combination of
draw

* CLA

* Machining allowance

* Lay

* waviness height

* waviness spacing

* Production method

* CLA

* Machining allowance

* Lay

* λ (L) $\rightarrow$ width of roughness
(Cite, SEE, NEET)

$$\nabla \Rightarrow \frac{R_a(CLA)}{8-25 \mu(\text{microns})}$$

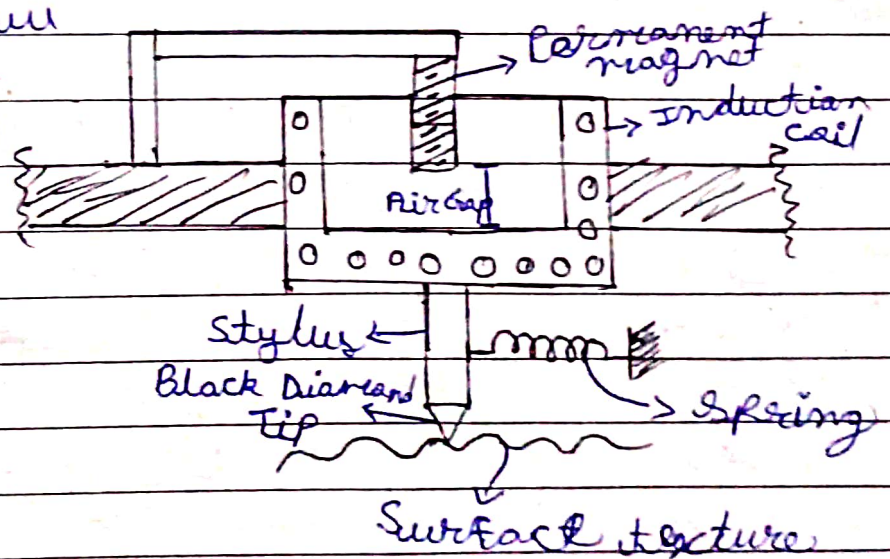
$$\nabla \nabla \Rightarrow 1.6-8 \mu(\text{microns})$$

$$\nabla \nabla \nabla \Rightarrow 0.025 \mu - 1.6 \mu(\text{microns})$$

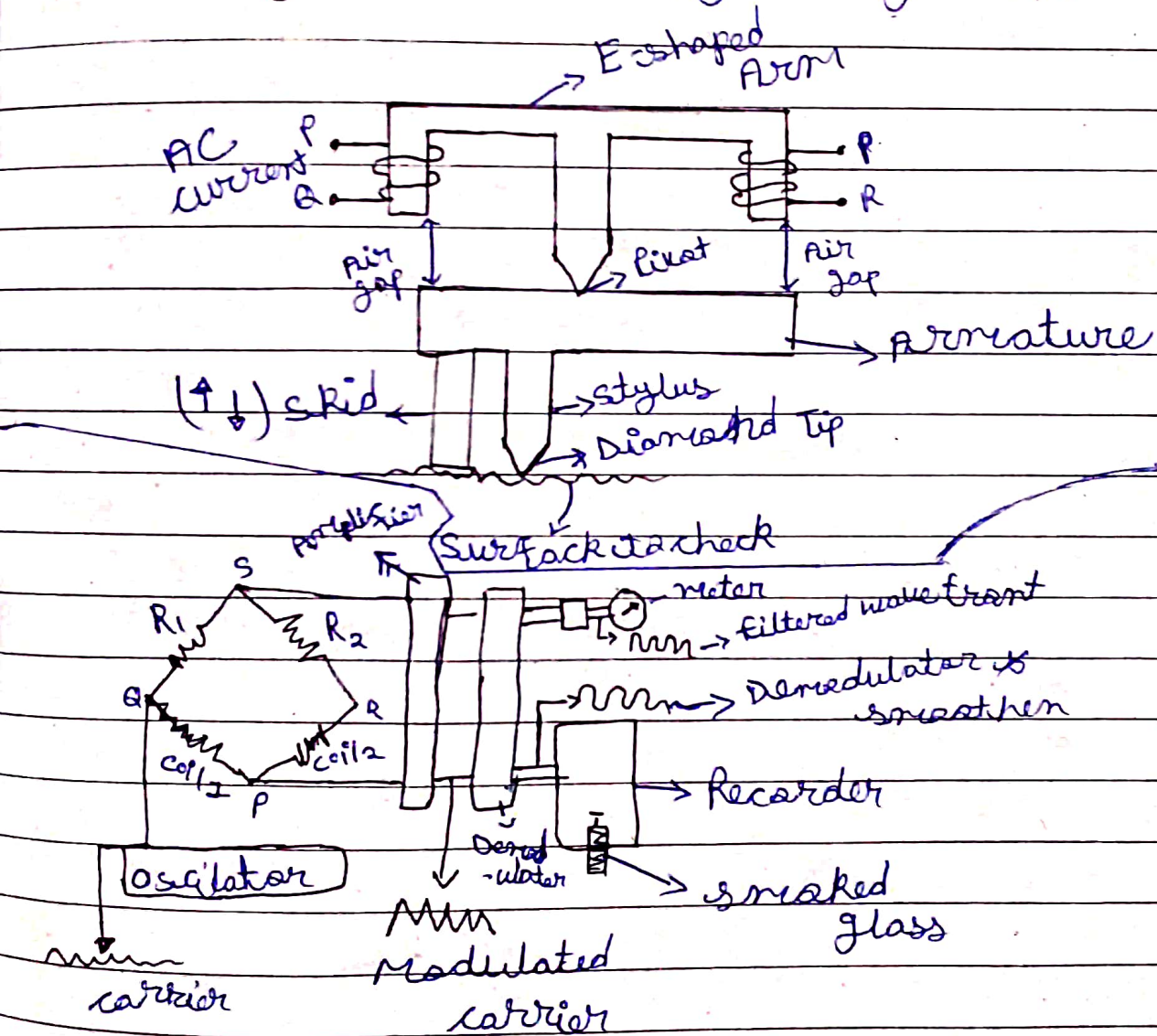
$$\nabla \nabla \nabla \nabla \Rightarrow < 0.025 \mu(\text{microns})$$

* Measuring Instrument of Surface roughness: ^{characteristic}

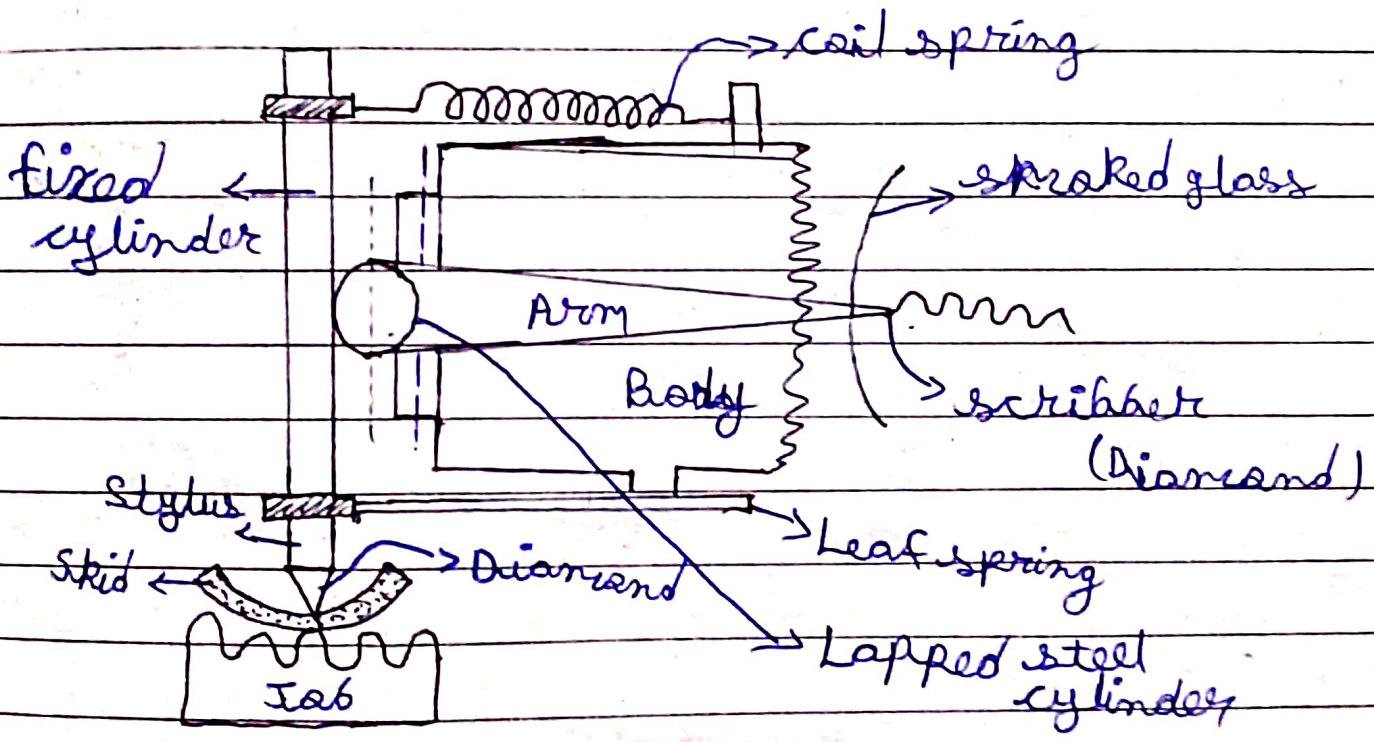
:- (i) Profilometer :- ^{slow}



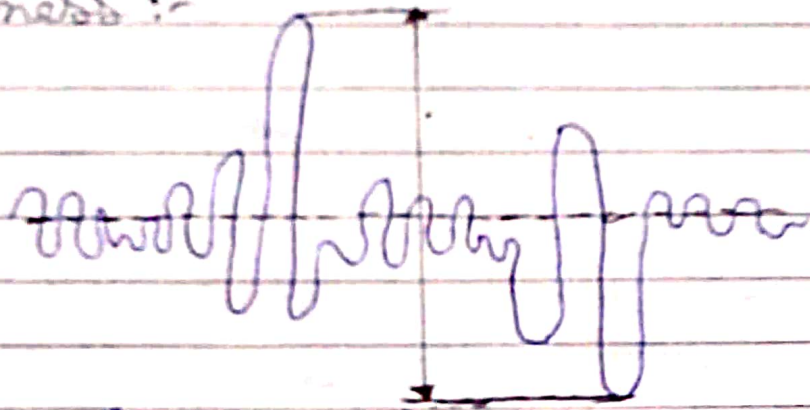
Q-2) Talysurf :- ^{slan} ~~Faly~~ Taylor Hobson



:- 3) ^{slow} Taelinse surface meter :-



* Straightness :-



A line is said to be straight over a given length if the variation of the distance of its points from two planes perpendicular to each other, and parallel to the generation direction of the line, remains within the specified tolerance limit.

→ It is ~~the measurement of a~~ one dimensional measurement of a linear deviation from a perfect alignment.

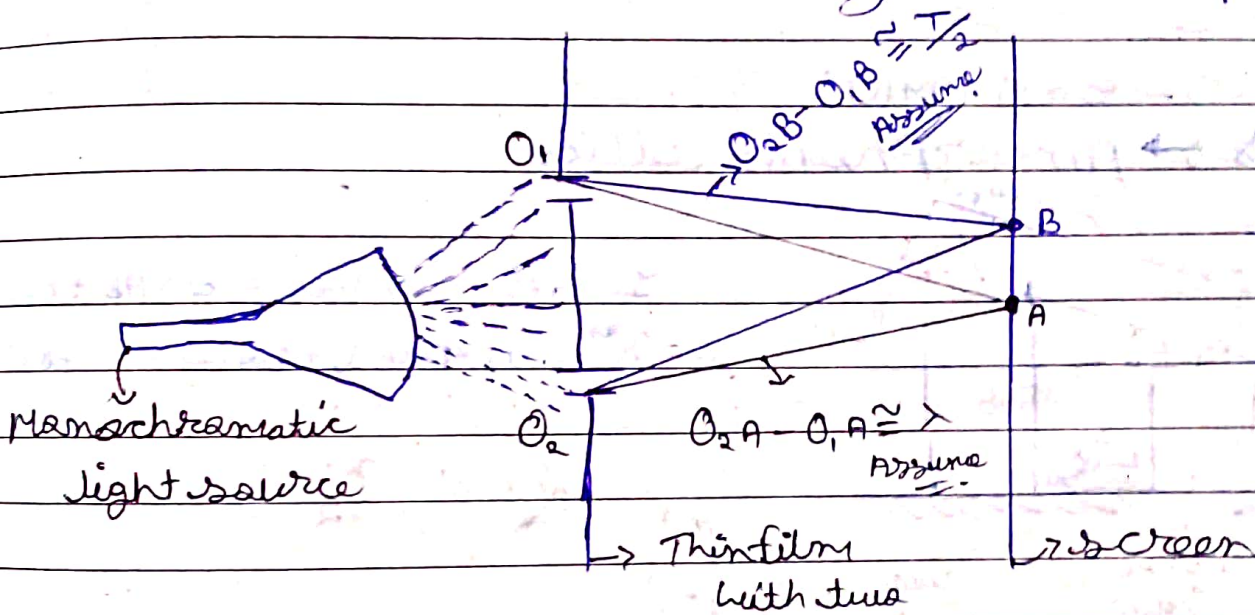
⇒ straightness is a 2D concept. (2 dimensional concept).

⇒ flatness can be seen as 3D (3 dimensional extension of straightness).

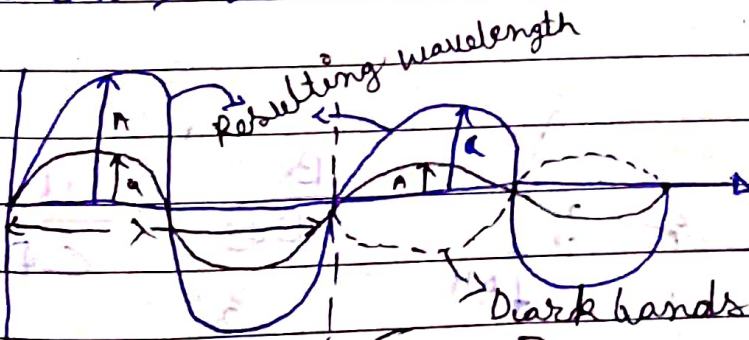
:- Methods of straightness measurement :-

- ✓ ① Wedge Method
- ② Spirit level method
- ✓ ③ Auto collimator method
- ④ Beam comparator Method.

* Interferometry & optical flat :- {Ordinarily used in Engineering Metrology?}



O_1 & $O_2 \Rightarrow$ Two holes in thin film



λ = wavelength of monochromatic light

Constructive waves length $[A < a] \rightarrow$ Amplitude

Destructive wavelength

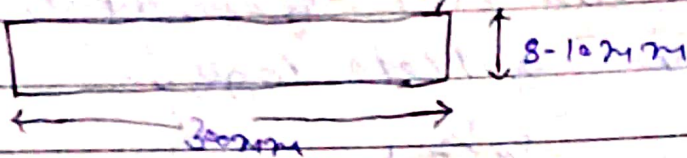
$[A > a] \rightarrow$ white bands / light band

$\rightarrow 0, \lambda, 2\lambda, \dots \Rightarrow$ constructive wavelength $\hookrightarrow$ light bands

Path difference

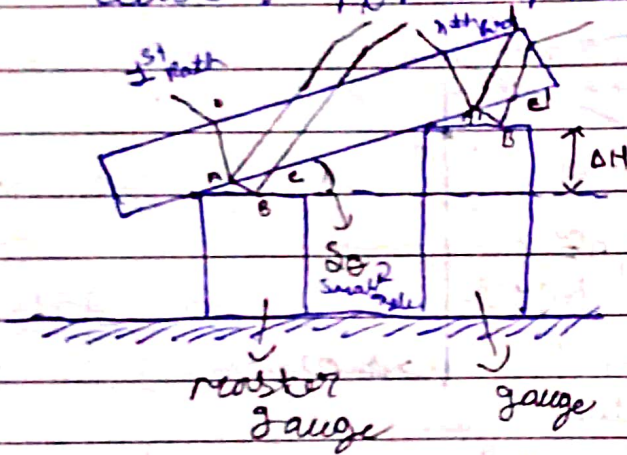
$\rightarrow \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \dots \Rightarrow$ Destructive wavelength $\hookrightarrow$ dark bands.

Quartz $\rightarrow$ crystalline silica



Boop - 25-50mm(t)

Glass $\rightarrow$ Amorphous silica

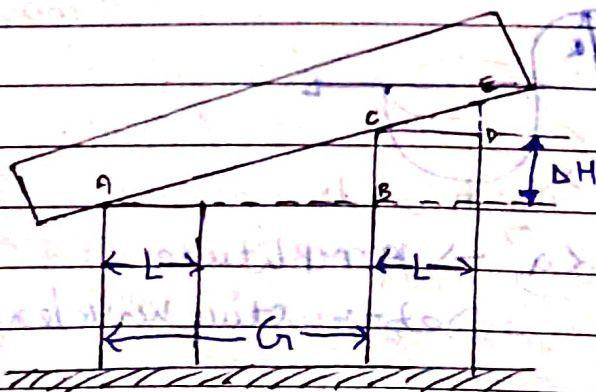
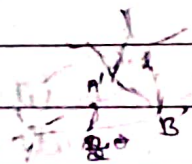


λ path $\Rightarrow$ path difference = $AB + BC$

$n\lambda = n^{\text{th}}$ path $\Rightarrow$ path difference = $A'B' + B'C'$

$A'B' \approx B'C'$ $2A'B' = n\lambda$

$$A'B' = \frac{n\lambda}{2}$$



$$\frac{BC}{DE} = \frac{AB}{CD} = \frac{\Delta H}{L}$$

$$\Delta H = \frac{n\lambda}{2} \left(\frac{G}{L} \right)$$

n = no. of bands

G = gauge mounting with difference

L = gauge width

λ = wavelength of monochromatic light.