CBCS SCHEME

USN ☐☐☐☐☐☐☐☐☐☐ **BME402**

Fourth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025

Machining Science and Metrology

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

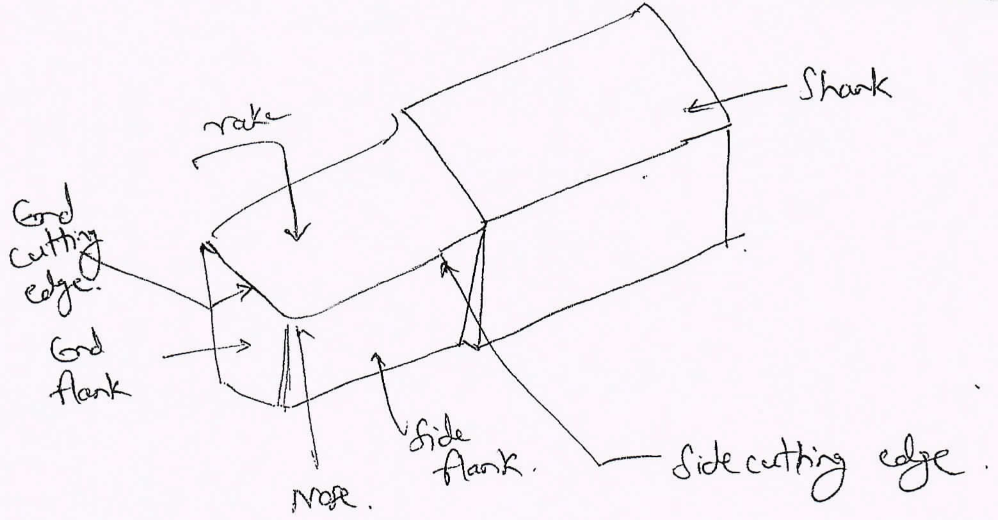
		Module – 1	**M**	**L**	**C**
Q.1	**a.**	With a neat sketch, explain single point cutting tool geometry.	**07**	**L2**	**CO1**
	b.	Explain the merchant circle diagram for the analysis of power requirement for the machine tool.	**08**	**L2**	**CO1**
	c.	Describe the orthogonal and oblique cutting.	**05**	**L2**	**CO1**
		OR			
Q.2	**a.**	With neat sketches, explain the tool layout for producing a hexagonal bolt on a capstan lathe.	**07**	**L2**	**CO1**
	b.	Briefly discuss the broad classification of lathes.	**07**	**L2**	**CO1**
	c.	Explain any two operations of the lathe.	**06**	**L2**	**CO1**
		Module – 2			
Q.3	**a.**	With a neat diagram, explain column and knee type milling machine.	**07**	**L2**	**CO2**
	b.	Explain with neat sketches up milling and down milling methods of milling operations. Discuss the significance of both.	**08**	**L2**	**CO2**
	c.	Use compound indexing method for calculating the index crank movement to divide the peripheral of a job into 87 divisions.	**05**	**L3**	**CO2**
		OR			
Q.4	**a.**	Explain with neat sketch constructional features of radial drilling machine.	**08**	**L2**	**CO2**
	b.	Explain driving mechanisms of shaper.	**06**	**L2**	**CO2**
	c.	Briefly explain the classification of grinding machines.	**06**	**L2**	**CO2**
		Module – 3			
Q.5	**a.**	Define tool life. Discuss the parameters which influences the tool life.	**08**	**L2**	**CO3**
	b.	With a neat sketch, explain the different heat zones that are present during the metal cutting process.	**06**	**L2**	**CO3**
	c.	Discuss the different wear mechanisms.	**06**	**L2**	**CO3**
		OR			
Q.6	**a.**	List the different types of cutting tool materials and explain them.	**08**	**L2**	**CO3**
	b.	Explain different properties of cutting fluids.	**06**	**L2**	**CO3**
	c.	Define machinability and discuss the factors affecting machinability.	**06**	**L2**	**CO3**
		Module – 4			
Q.7	**a.**	Discuss the following standards of measurement: (i) Line standard (ii) Wavelength standard (iii) End standard	**07**	**L2**	**CO4**
	b.	With a neat sketch, explain international prototype meter.	**07**	**L2**	**CO4**
	c.	Explain wringing phenomenon.	**06**	**L2**	**CO4**
		OR			
Q.8	**a.**	Define fit. Describe the types of fit and their designation.	**08**	**L2**	**CO4**
	b.	What is the purpose of limit system?	**06**	**L2**	**CO4**
	c.	With a neat sketch, explain snap gauges.	**06**	**L2**	**CO4**

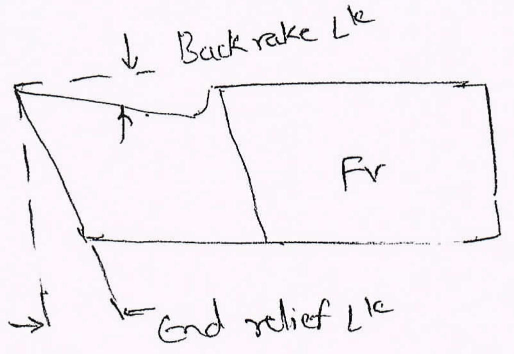
Module – 5					
Q.9	**a.**	With a neat sketch explain Taylor's principle in the design of limit gauges.	**08**	**L2**	**CO5**
	b.	Sketch and explain two types of plug and ring gauges.	**08**	**L2**	**CO5**
	c.	Explain briefly the different gauge tolerances.	**04**	**L2**	**CO5**
OR					
Q.10	**a.**	Explain the basic characteristics and classification of comparators.	**06**	**L2**	**CO5**
	b.	With a neat sketch, explain sigma comparator.	**08**	**L2**	**CO5**
	c.	Explain the principle and working of a sine bar.	**06**	**L2**	**CO5**

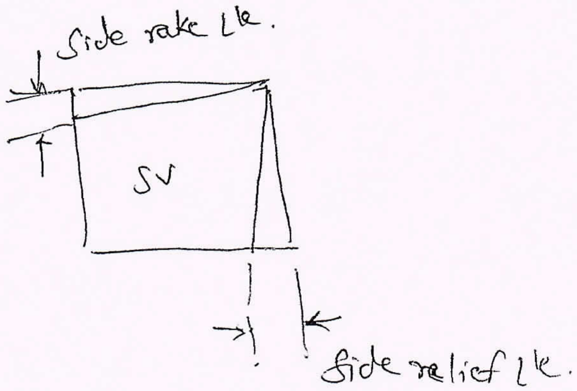
* * * * *

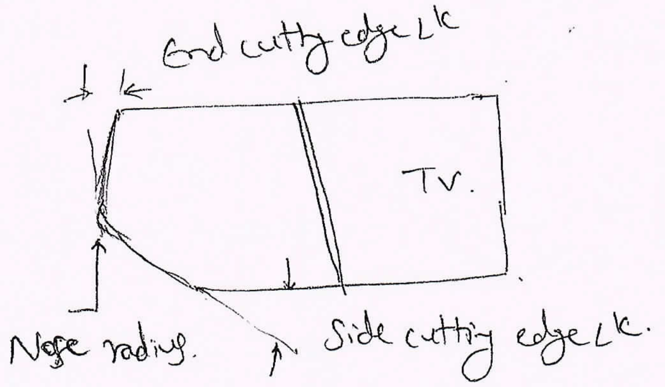
Q1.a

Single point tool geometry – Tool Signature









Tool Signature.

1) – Back rake ∠le
2) – Side " "
3) – End relief ∠le
4) – Side " "
5) – End cutting edge ∠le
6) – Side " " "
7) – Nose radius.

Rake ∠'s - decide the power consumption
Penetration inside the material
Chip flow

Relief ∠'s - to avoid rubbing of tool with machined surface
" " " " " " unmachined "

Cutting edge ∠'s - inclination of side & end cutting edges
decide the power consumption.
Sometimes geometry of w/p.

Nose radius - to enhance tool life.
to enhance heat dissipation
to improve surface finish.

Tool signature ex:

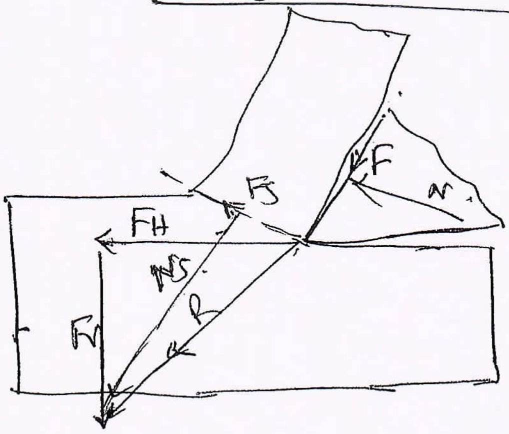
Tool signature is the identity or uniqueness of the tool depicting the Various geometry angles and nose radius of the tool.

5, 6, 8, 7, 10, 15, 0.4.

Back rake ∠ᴸᵉ → 5°
Side rake ∠ᴸᵉ : 6°
End relief ∠ᴸᵉ : 8°
Side relief ∠ᴸᵉ : 7°
End cutting edge ∠ᴸᵉ : 10°
Side cutting edge ∠ᴸᵉ : 15°
Nose radius : 0.4 mm.

Q1b.

Analysis of machining forces & power requirement using Merchant circle diagram.



R - resultant force.

F_V = vertical component of force (⊥r to tool motion).

F_H = Horizontal " " "

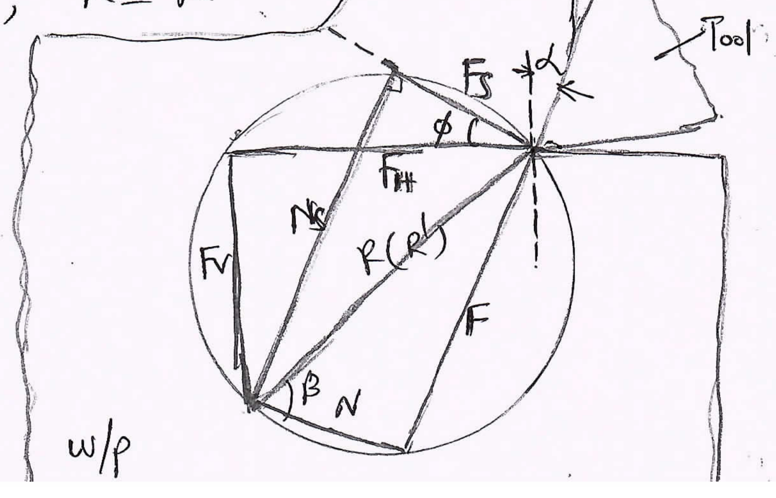
N_S = Force normal to shear plane

F = Friction force along rake face.

N = Normal force ⊥r to rake face.

When the chip is isolated as a freed body diagram, we need to consider only 2 forces, the force b/w the tool face & chip (R) and the force between the workpiece & chip along shear plane (R').

For equilibrium, R = R'.



The various force components are as below:

$F_S = F_H \cos\phi - F_V \sin\phi.$

$N_S = F_V \cos\phi + F_H \sin\phi.$

$= F_S \tan(\phi+\beta-\alpha).$

ϕ = shear $\angle$le
β = friction $\angle$le
α = rake $\angle$le

$F = F_H \sin\alpha + F_V \cos\alpha$

$N = F_H \cos\alpha - F_V \sin\alpha.$

Co-efficient of friction, μ is given by

$$\mu = \tan\beta = \frac{F}{N} = \frac{F_V + F_H \tan\alpha}{F_H - F_V \tan\alpha}.$$

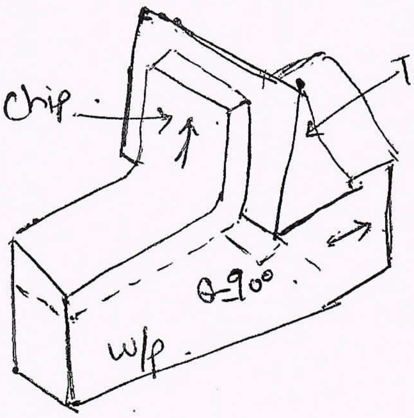
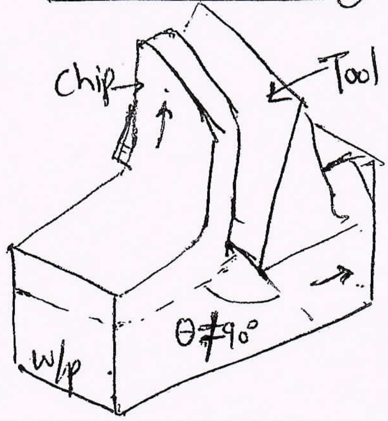
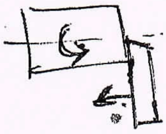
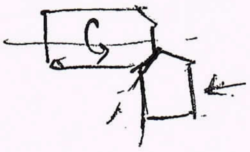
Power or energy consumed

= Cutting force × cutting velocity

$= F_H \times V.$

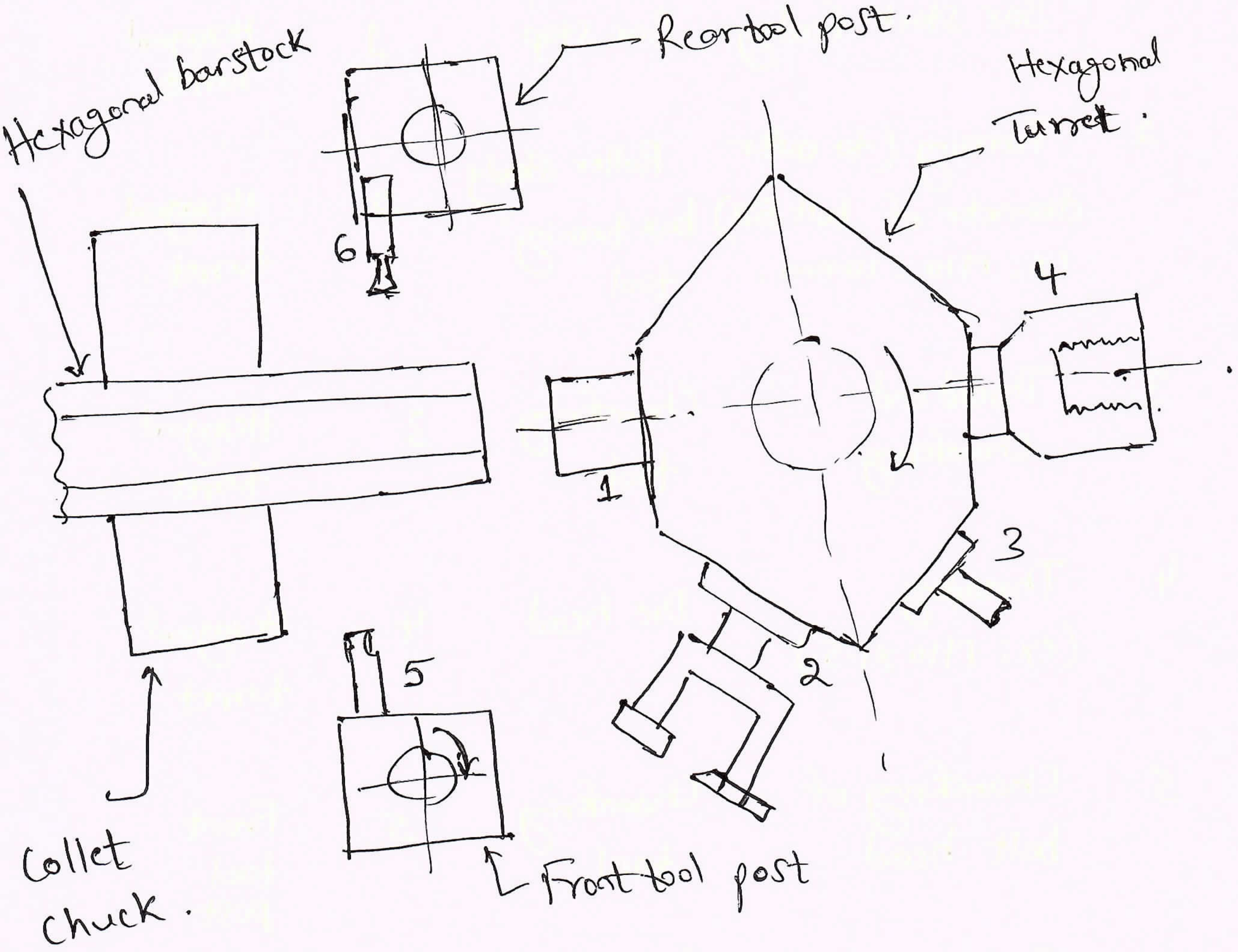
[Note: V should be in m/s]

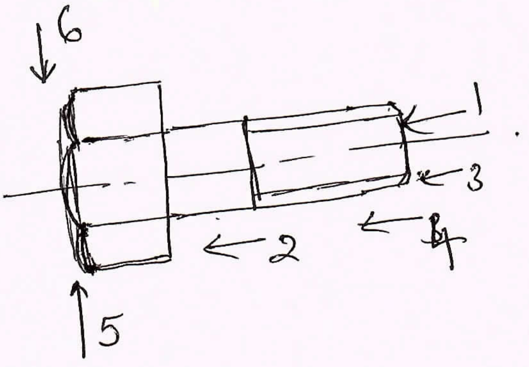
Q1.c.

Orthogonal cutting	Oblique cutting.
	
→ Cutting edge of tool is inclined @ 90° to velocity vector	→ Cutting edge of tool is incline at other than 90° to velocity v
→ 2 dimensional system	→ 3 dimensional system.
→ Chipflow is @ 90° to cutting edge	→ Chip flow is @ other than 90° to cutting
- Ex: End turning/facing with a tool - side cutting edge ∠le =0°. 	Ex: Practically most of operations involve oblique cutting. 

- Orthogonal cutting is less complicated system (forces resolved in 2 axes) and is usually used for study & research purpose. Oblique cutting is a 3 dimensional system and comparatively complex process for study and analysis.

Q2.a. With neat sketch explain the tool lay out for producing a hexagonal bolt on capstan lathe





P.T.O.

Sl. No.	Operation Description	Tool	Tool no; [illegible]	Tool Position
1.	Bar stock feeding.	Bar stop	1.	Hexagonal Turret.
2.	Turning (to outer diameter of bolt size) ex: M10 : 10mm.	Roller steady box turning tool	2.	Hexagonal turret.
3.	Thread end chamfering	Chamfering tool.	3	Hexagonal turret.
4.	Threading. (ex: M10 x 1.5)	Die head	4.	Hexagonal turret
5.	Chamfering of bolt head	Chamfering. tool	5	Front tool post
6.	Parting	Parting tool	6	Rear tool post.

Q2.b. **Classification of lathes:**

1) Bench lathe: Small lathe which can be mounted on bench and used for small & light operations. usually used in small workshops.

2) Engine lathe or Centre lathe: Higher capacity lathes which have got 2 centres [live centre & dead centre], hence the lathe is termed as centre lathe. Previosly these were driven by engines, hence the name engine lathe. Now they are equipped with induction motor.

3) Capstan lathe: Lathe used for mass production, where tailstock is replaced with hexagonal turret. [usually smaller in capacity].

4) Turret lathe: This lathe is larger than capstan lathe and is used for heavier jobs/works. ||| in construction to capstan lathe, but turret is directly mounted on machine saddle. It is also used for mass production.

P.T.O.

5) Automatic lathe : This type of lathe is used in mass production, Here most of manual activities like raw material loading / unloading of jobs, feed etc are controlled automatically using certain mechanisms.

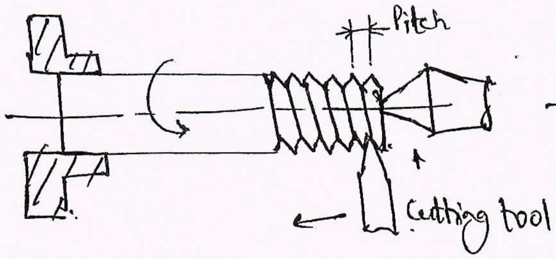
6) CNC Lathes & turning centres: Computer numerical control lathes, equipped with machine control unit and other accessories are used to control the operations of machine using a program. They are equipped with servo motors for spindle & axes, hydraulic mechanism for clamping/tailstock movement, turret (multiple tool holding), coolant system, lubrication system etc.

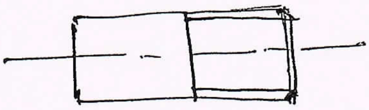
7) Vertical lathes : Axis of rotation is vertical. Such lathes are meant for machining very large diameter and heavy jobs. Usually these are CNC / PLC controlled.

Q2. C.

2 Operations on lathe:

1) Threading / Thread cutting:

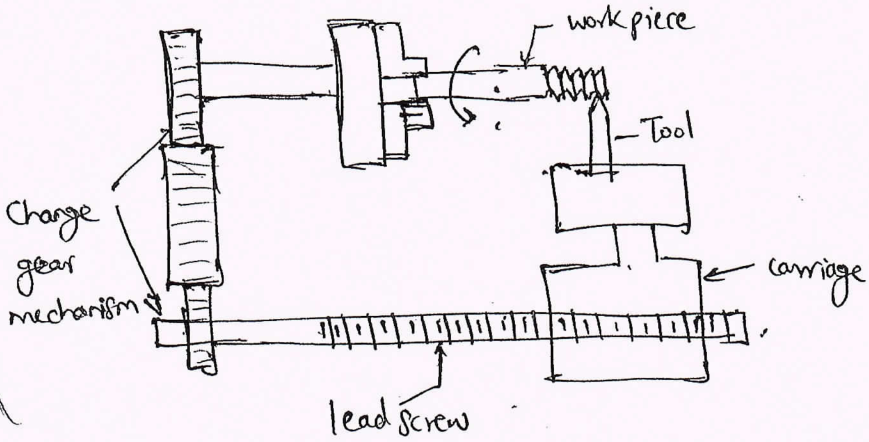




"Thread is a helical groove formed on cylindrical or conical rod."

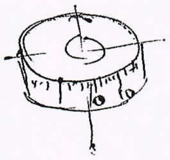
- Thread cutting is done on lathe when tool of shape of thread is moved longitudinally with uniform linear motion while the workpiece is rotated with uniform speed.
- For threading, workpiece is supported with dead centre & rotated @ slow speed.
- Carriage / Saddle is engaged with lead screw for uniform automatic motion.
- A definite ratio b/w longitudinal feed of tool & rotation of headstock spindle (workpiece rotated by spindle) will ensure machining of threads of required pitch. This is effected by change gear mechanism.

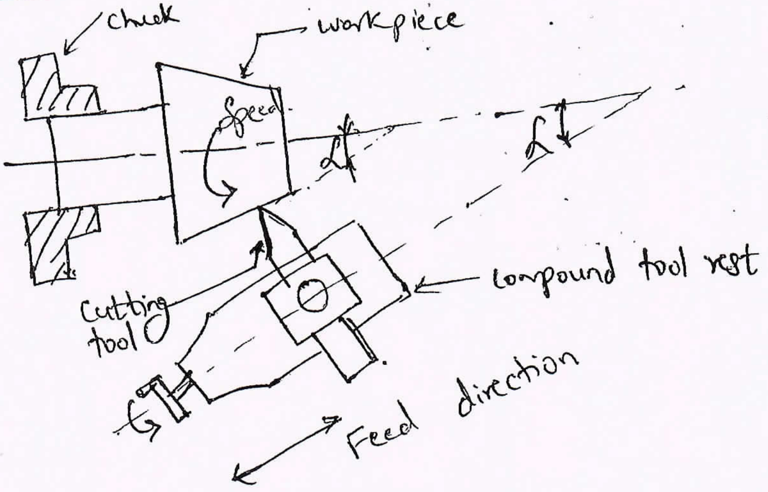
for reference only

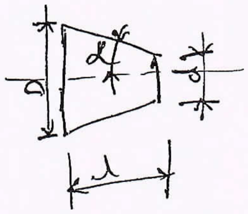


- For every rotation of workpiece, tool will move by 1 pitch distance.

2) Taper turning by swiveling of compound tool rest:



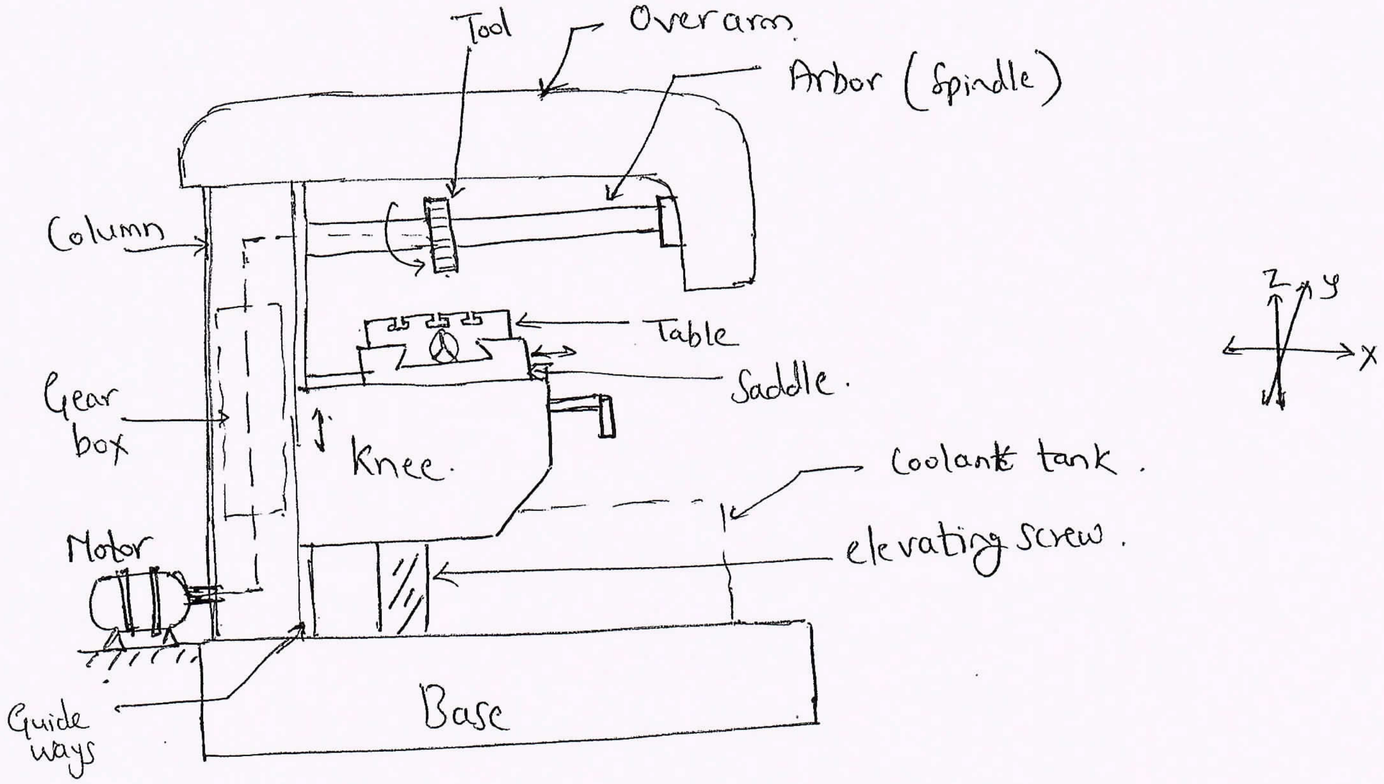




Conicity,
$K = \frac{D-d}{l}$

- workpiece is clamped in the chuck.
- Compound tool rest is swirled (rotated) by required taper ∠le & is locked in that position. Markings on the compound tool rest help for accurate alignment.
- workpiece is rotated & cutting tool is fed against the workpiece by sliding the compound tool rest.
- This is used for workpieces which require steep taper for short lengths.

Q3.a. Horizontal Milling Machine.- Column & knee type



Principal parts of horizontal milling m/c. :
(Column & Knee type)

- Base
- Column
- Overarm
- Knee
- Saddle
- Table
- elevating screw
- Motor
- Gearbox.

→ This machine is called so, because it consists of column (where spindle is fixed) and knee which holds the work table.

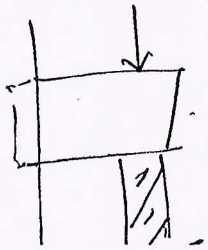
→ The base supports all the other parts and may also act as reservoir for cutting fluid.

→ Knee moves up & down in the guideways provided on the column and elevating screw helps for movement A saddle is mounted on the knee, over which work ta is mounted.

→ The column houses the motor, gear arrangement required for adjustment of speeds. The spindle is mounted horizontally in the column & overarm with the help of bearings. The cutter is mounted on the spindle.

→ Although the m/c is rigid to hold the workpieces of medium to large size, extemely large components cannot be machined, ∵ of the weight limitations.

This is used for slab milling slot milling & gear cutting operati

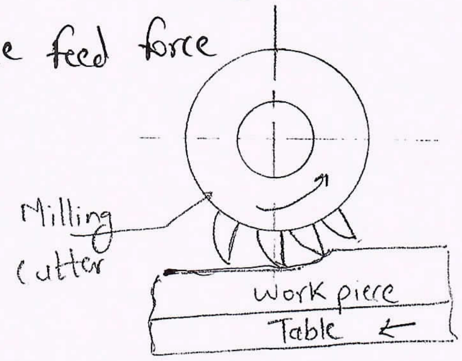


Q3b. **Milling process: (Methods)**

*** Up milling or Conventional milling:** (Milling process where in the cutter rotates against the direction of feed of work piece.

F_1 = force exerted by cutter

F_2 = Table feed force



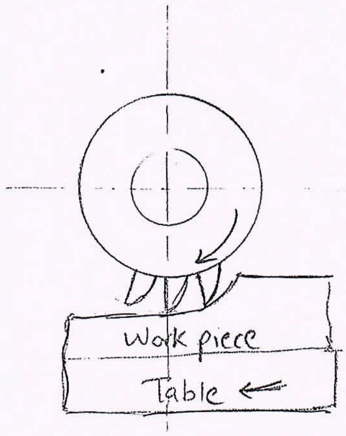
$\xrightarrow{F_1}$

$\xleftarrow{} F_2$

net force = $F_1 \sim F_2$

- In conventional milling cutter directic is just as to lift the workpiece fro fixture.
- Cutting force is higher @ the end o cut.
- Chips accummulate ahead of cuttin region.
- chip thickness - highest @ e
  ∴ Temp is high & chance of welding to

*** Down milling or clamp milling:** Milling process where in the cu rotates inline with the feed of work (climb milling)



← F_1

← F_2

net force = $F_1 + F_2$

- Cutter direction is just as to force the workpiece against fixture.
- Cutting force is high @ the begining of cut.
- Chip thickness highest in the begining.
- Surface finish & chip disposal is better.

Upmilling is practiced on conventional machines, which are less rigid & withstand lesser forces generated in machining. ($F_1 \sim F_2$).
Down milling is practiced on CNC machines & rigid machines which can withstand higher force ($F_1 + F_2$)

Q3C.

Ex: Calculate indexing required for making 87 divisions.

87 divisions cannot be simple indexed. Hence compound indexing has to be done. $Z = 87$.

$$4 = \cancel{2} \times \cancel{2}$$

$$87 = \cancel{29} \times \cancel{3}$$

difference

$$40 = \cancel{2} \times \cancel{2} \times 2 \times 5$$

$$29 = \cancel{29} \times 1$$

$$33 = 11 \times \cancel{3}$$

2 numbers selected are 29 & 33.

All the factors above the line cancel out. ∴ 29 & 33 hold good for compound indexing.

Product $= 2 \times 5 \times 1 \times 11 = 110$.

Compound indexing equation : $\dfrac{n_1}{N_1} \pm \dfrac{n_2}{N_2} = \dfrac{40}{87}$

$$\frac{n_1}{29} \pm \frac{n_2}{33} = \frac{40}{87}$$

To find out n_1 & n_2 →

$$\frac{110}{29} \pm \frac{110}{33} = \frac{40}{87}$$

(110 is the product of uncancelled factors below the line).

By calculation, we can conclude that − sign holds good.

$$\therefore \frac{110}{29} - \frac{110}{33} = \frac{40}{87}$$

$$3\frac{23}{29} - 3\frac{11}{33}$$

$$\boxed{\frac{23}{29} - \frac{11}{33} = \frac{40}{87}}$$

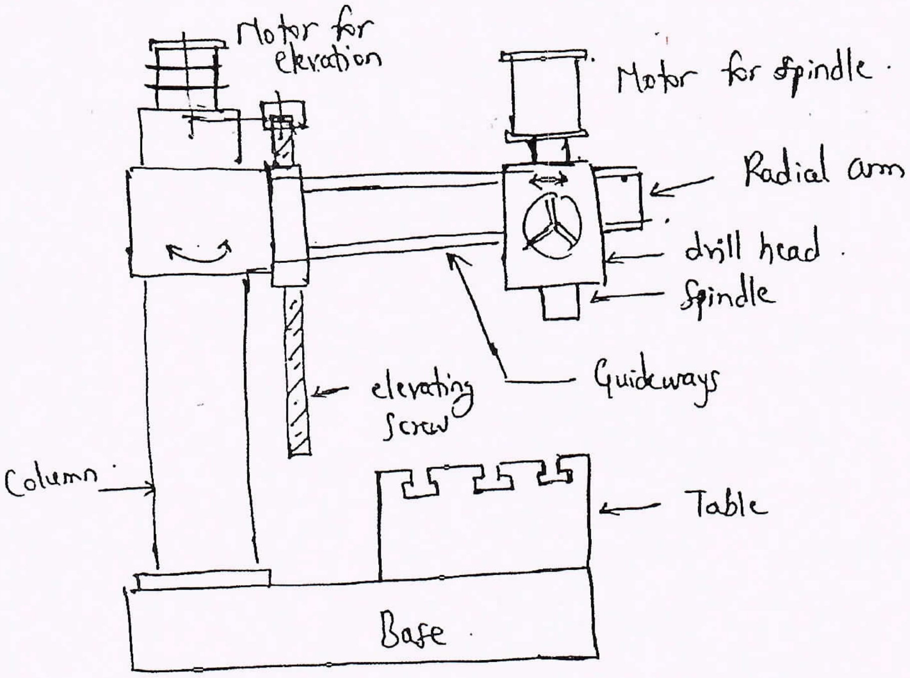
Required indexing equation.

∴ $n_1 = 23$, $N_1 = 29$

$n_2 = 11$, $N_2 = 33$

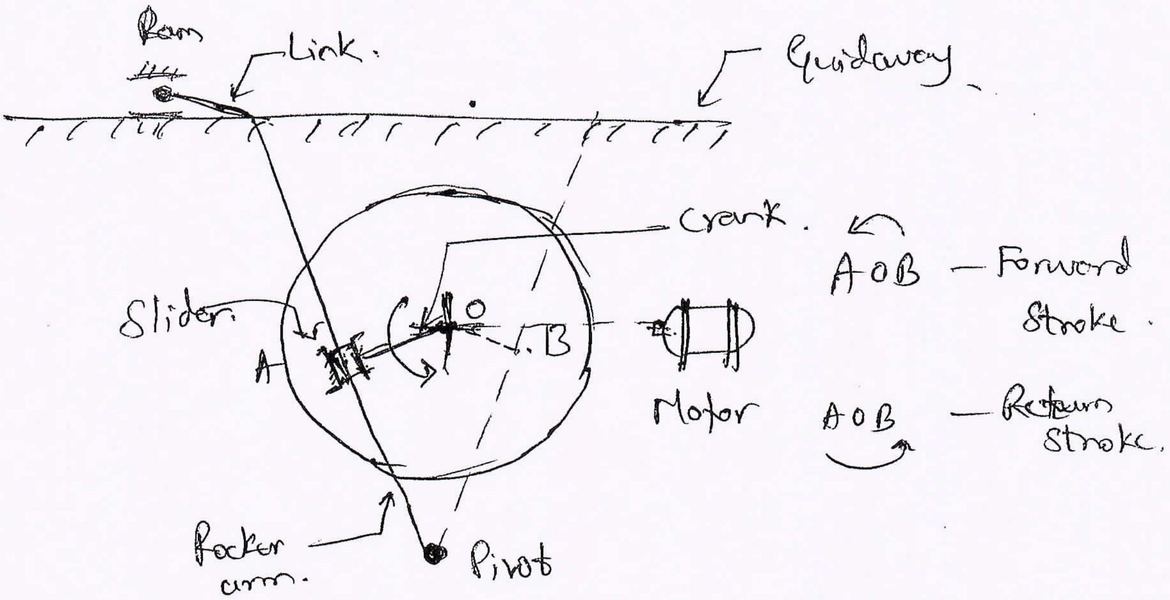
Drilling Machines

Q4a. **Radial drilling m/c :**



- Radial drilling m/c consists of base, column, table, radial arm, drill head and 2 motors.
- 1 motor for up & down movement of radial arm & 1 motor for drive spindle
- Radial arm can swing about the cylindrical column for carrying the spindle to required point
- Drill head consisting of motor, drive spindle & feed arrangements moves over the guideways of radial arm.
- Table is mounted on the base and the workpiece can be fixed on the table with the help of fixture / vise / clamps.
- Drilling can be done at any point within the area of reach of radial arm.

Q4b. Driving mechanism of shaper / [redacted]



The major motions required in the m/c are reciprocating motion of cutting tool & auxiliary motion. During forward stroke, the cutting is performed and return stroke is idle. Forward stroke takes more time, return stroke takes less time. Hence quick return mechanism is planned. Ram of the m/c moves in guideways. A link connects ram & rocker arm, which pivots about a point. A crank rotates with drive from motor [through gearing], it is connected to slider, which slides in the slot of rocker arm. Rotary movement is converted into reciprocatory movement. Forward stroke is traced by $\overleftarrow{AOB}$ (obtuse $\angle^{le}$) indicating that it is slow & takes more time. Return stroke is traced by $\underset{\curvearrowright}{AOB}$. (comparatively lesser. $\angle^{le}$), indicating that it is fast (∵ of idle stroke).

(Refer hydraulic mechanism also)

Q4. c. **Classification of grinding machines / Process**

1) Surface grinding machine

(To grind flat surfaces)

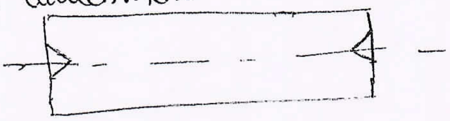
a) Horizontal spindle

b) vertical spindle

2) Cylindrical grinding machine

(To grind cylindrical components with centre holes)

or some attachment

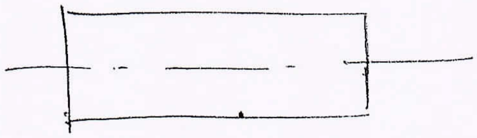


a) External cylindrical grinding m/c

b) Internal " " " (for hollow components)

3) Centreless grinding machines

(To grind cylindrical components without centre holes)



[No provision for centre holes in component]

4) Special purpose grinding machines.

— designed and developed for specific component design.

Ex: Crankshaft grinding
Camshaft "

Q5a. **Tool life:** Tool life represents useful life of the tool expressed generally in time units from the start of cut to endpoint defined by tool failure criterion. It is the useful time the tool is used for machining effectively.

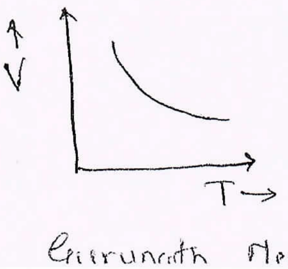
- For reusable tools (HSS) it is the life measured b/w 2 successive regrindings.
- For throw away inserts (carbides/ ceramics) it is the time measured b/w the change of cutting edges.

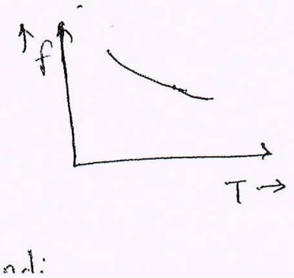
Effect of various parameters on tool life: **Variables affecting tool life**

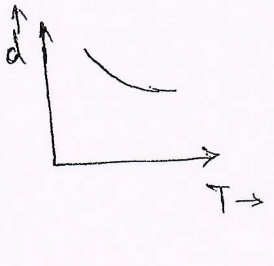
1) **Cutting conditions** – Speed, feed, depth of cut:

	Effect	Consequence
a) Increase in cutting speed	increase in tool temp, Softening of tool, abrasion & adhesion wear	tool life reduces
b) Increase in feed	greater cutting force, higher temp & tool wear	tool life reduces.
c) Increase in depth of cut	increase in area of chip tool contact, little increase in temp	tool life reduces.

Note: out of the 3, cutting speed has higher impact, then feed and lastly the depth of cut.







Gurunath [illegible]:

2) Tool material properties: The tool material properties which enhance tool life are:

- a) high hot hardness
- b) toughness
- c) wear resistance
- d) high thermal conductivity & specific heat
- e) lack of chemical affinity w work material

3) Coating of tool with materials like TiC, TiN, $TiC + Al_2$ enhances the tool life.

4) Work material properties: The work material propertie that increase the tool life are:

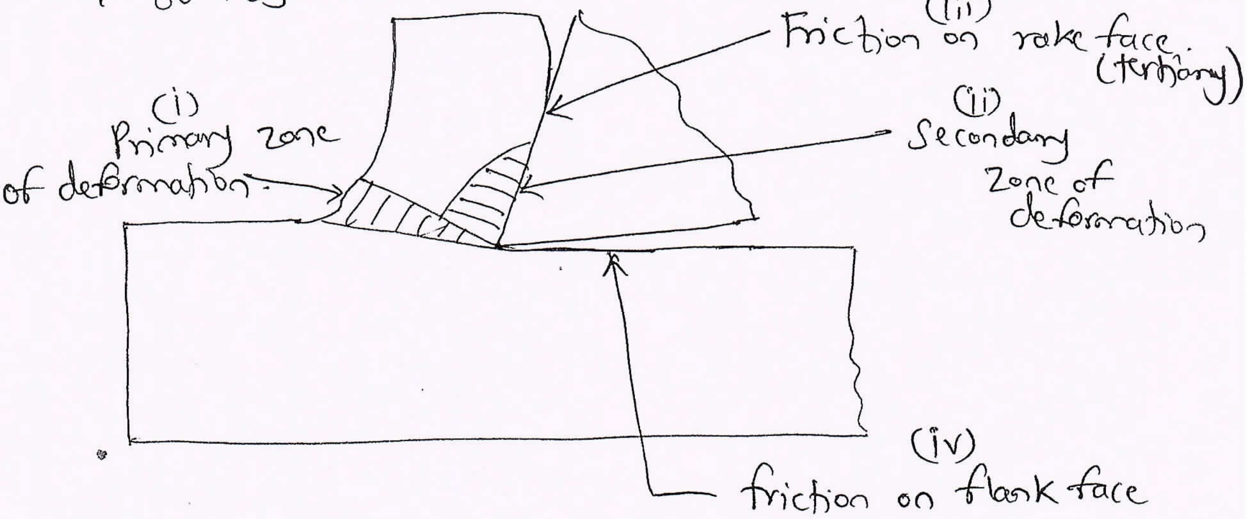
- a) low strength and hardness
- b) Absence of abrasive constituents (scaling, sand, slag inclus
- c) Presence of additives like lead (which acts as lubrican
- d) favourable microstructure: ex: Cast iron containing free graphite increases tool life, while free iron carbide is harmful to tool life.

5) Tool geometry:

	Effect
Increase in rake ∠le	Tool life initially increases and then decreases
Increase in relief ∠le	Tool life initially increases & then decreases
Increase in nose radius	Tool life increases

Q5b. **Heat Zones present during the metal cutting process**

Cutting process involves severe plastic deformation in the primary & secondary zones and rubbing on tool rake & flank face. The work done in causing plastic deformation gets converted into heat. Friction of chip with tool and tool with work also produces heat. All these 4 sources



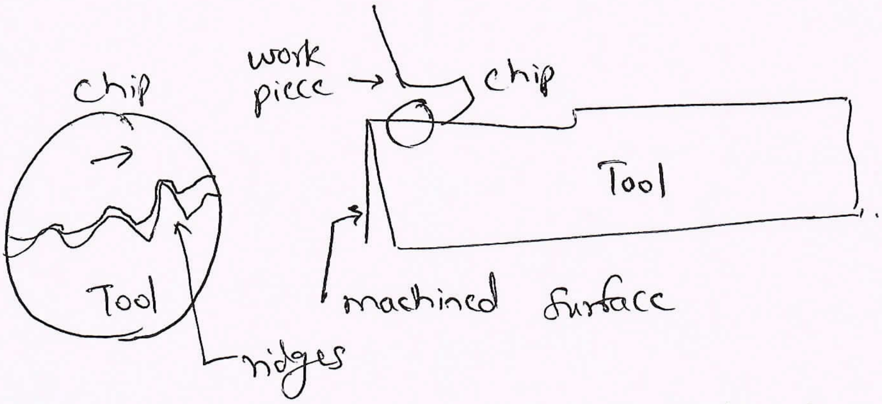
Sources of heat generation in metal cutting.

Of the total energy consumed, maximum energy (nearly 80%) is consumed in primary & secondary zones of deformation. The energy loss in friction at rake face is nearly 18% and friction loss at flank face is about 2%.

Gus

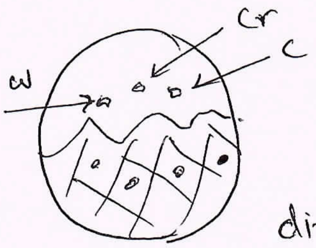
Q5c. Different tool wear mechanisms

1) Shearing at high temperature



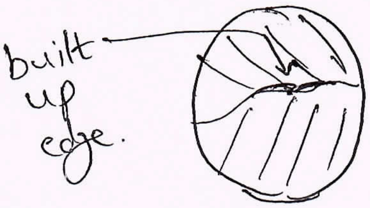
when chip moves over the tool, ridges/asperities will interlock. Workpiece will be work hardened and tool may become soft at high temperature. This causes yielding of tool material.

2) Diffusion wear.



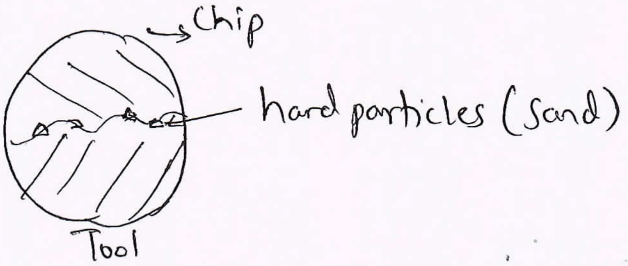
The tool contains alloying elements like Chromium(Cr), tungsten(W), Carbon(C), Molybdenum (Mo). These alloying elements may diffuse into chip ∵ of concentration gradient, which is termed as diffusion wear.

3) Attrition (Adhesion) wear:



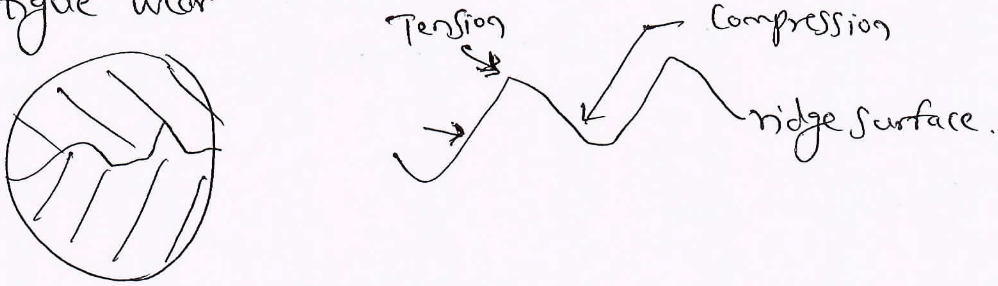
The soft chip material may weld to tool material - layer by layer, which is termed as built up edge(BUE). This BUE will become unstable and torn away from tool. Then some particles/portion of tool will adher to BUE, this wear is called adhesion wear.

4) Abrasion Wear



Some workpieces contain hard particles (ex sand in castings). These hard particles rub on rake & flank surfaces of tool & create ploughing action. The tool material is worn out by abrasion action.

5) Fatigue wear



The asperities on the ridge surface are subjected to different types of forces [tension on one side & compression on other]. When new surfaces are formed, the asperities may be subjected to different type of loading. This causes fatigue failure of tool material on the surface.

Q 6. a. The different types of tool materials are as under.

Tool material	Constituents	Application.
1) High carbon steel	C > 0.6%, Fe, traces of other elements.	hand tools, drills, taps
2) High speed steel. (HSS)		Single point tool, drill, milling cutter, broach, form tool, taps, allmost all types.
T-type →	Tungsten, Chromium, Vanadium, Iron. Cobalt,	
M-Type →	Molybdenum, Chromium, Cobalt, Vanadium.	
3) Cemented carbide	Tungsten carbide + Cobalt. (powder metallurgy).	Tool inserts, solid carbide drills.
4) Ceramics / Cermets	Al_2O_3 + traces of Zirconium oxide, tantalum oxide.	Tool inserts.
5) Cubic boron nitride (CBN)	Boron nitride (cubic structure)	Tool inserts for machining heat treated comp, Ni, SS, Superalloys, grinding wheel
6) Diamond.	Carbon. [hardest substance].	Tool tips for machining Al, composites, glass, fibers, grinding wheel. → Not used for machining of ferrous materials.

Cobalt – improves hot hardness

Chromium – enhances hardenability

Varadium – improves wear resistance

Tungsten } form carbides → high hot hardness

Molybdenum } form carbides → tougher

Q6.b. Desirable properties of cutting fluids:

In order to accomplish these functions, the cutting fluids should possess certain properties, These are as below:

- High heat absorption capacity : Enormous amount of heat is produced @ cutting zone, which needs to be taken away quickly.
- Chemical stability : It should not react with component, tool & machine parts.
- Low viscosity: Cutting fluid should flow easily, ofcourse some viscosity should be there that, it should wet the surface.
- Good lubrication property: It should act as lubricant between tool & workpiece & b/w tool & chip.
- High flash & fire points - It should not catch fire.
- It should not emit toxic fumes because of chemical reactions.
- It should be harmless to human beings. (should not cause skin diseases)
- No bad smell
- cutting fluid should be available @ optimum cost.

Q6. C. **Machinability**

The machinability refers to the ease with which a given work material can be machined under given set of cutting conditions. For ex: if material 'A' is easy to machine compared to material 'B', then material 'A' is said to have better machinability than material 'B'.

Various factors are:

a) hardness - Material with higher hardness is difficult to machine since it requires higher force and high hardness tool material. ex: Cast iron is harder than low carbon steel.

b) tool life - Material which offers higher tool life than other material, is said to have better machinability.

c) material constituents - Some material constituents give better machinability, for ex: presence of graphite flakes in CI act as coolant & presence of lead improves machinability in steels.

d) Coolant - Usage of coolant reduces cutting forces/heat, improves lubrication @ machining zone. ∴ It improves machinability.

Formula for machinability:

$$M_R = \frac{V^t_{60}}{V^s_{60}} \times 100$$

M_R = Machinability rating (%)

V^t_{60} = Specific cutting speed for 60 min tool life for test material.

V^s_{60} = SPS (SAE 1212) for 60 min tool life for standard material

Q7.a. **Line standard:** It is the standard used to measure or calibrate by measuring the distance between 2 engraved lines. According to it, the standard length of measurement is defined as distance between 2 scribed lines on a bar of metal under certain conditions of temperature & support.

ex: international prototype meter, yard, scale, measuring tape etc.

End standard: It is the standard used to measure or calibrate by measuring the distance between 2 end faces. The standards will be in the form of metal bar or block whose end faces are the standard distance apart.

ex: slip gauges, meter end bar, micrometer anvil, vernier calipers.

These are used to measure the distance b/w 2 parallel flat surfaces. They are used in laboratories & workshops for precision measurement.

P.T.O.

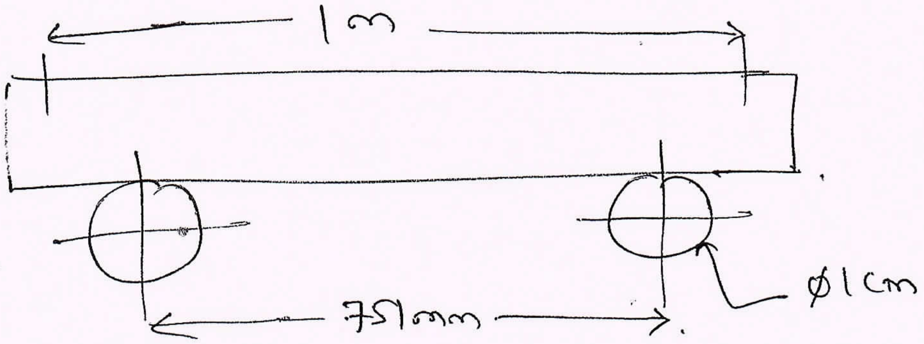
Wavelength Standard:

Here the standard of length is expressed interms of wavelength of certain radiation (ex: cadmium 114, Krypton 86, mercury 198). Kr 86 is the most suitable element if used in hot cathode discharge lamp maintained at 68°K temperature. In wavelength standard, the working standard is no more dependent upon the physical standard.

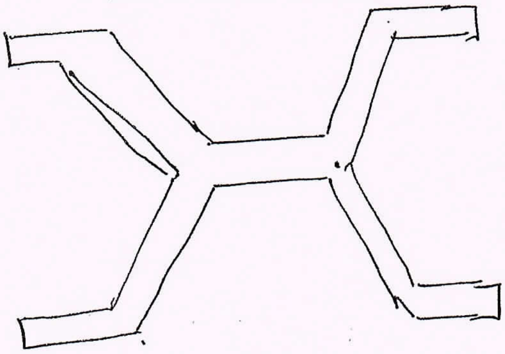
Metre = 1650763-73 X wavelength of radiation corresponding to transition b/w $2p_{10} - 5d_5$ of Kr86 atom in vacuum.

Q7 b.

Metre: This is the distance b/w the centre portions of 2 lines engraved on the polished surface of a bar of pure platinum - iridium alloy (90% platinum + 10% iridium). The bar is kept at 0°C & under normal atmospheric pressure. It is supported by 2 rollers of atleast 1 cm dia symmetrically situated in the same horizontal plane at a distance of 751 mm, so as to give minimum deflection.



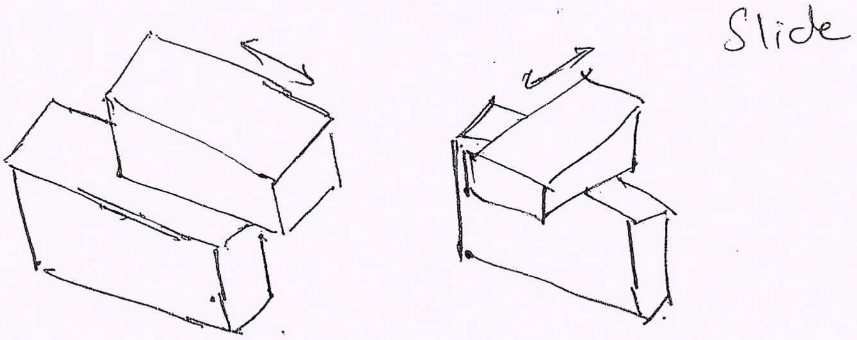
Cross section

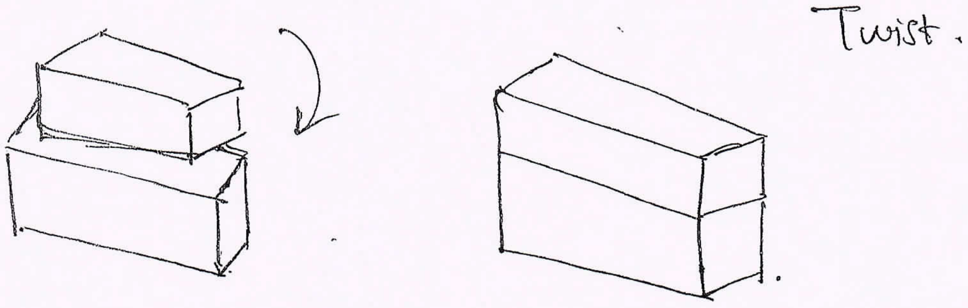


Q7.C. **Wringing phenomenon**

The term wringing refers to the conditions of intimate & complete contact and of permanent adhesion between measuring ~~p~~ faces which is brought about by wringing ~~together~~ the surfaces in question without application of pressure, assuming that the surfaces have been thoroughly cleaned & exhibit a good standard of flatness & smoothness.

It is believed that the phenomenon is due to molecular adhesion between a liquid film and the mating surfaces of the flat surfaces.





P.T.O.

Slip gauges are wrung together by hand through a combined blinding & twisting motion. First the gauge is oscillated slowly, with light pressure over other gauge so as to direct presence of any foreign particles b/w the surfaces.

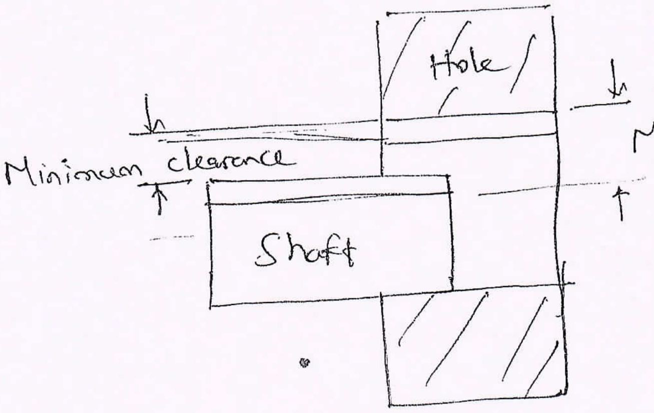
One gauge is then placed ⊥r to other & rotary motion is then applied until blocks are lined up.

Q8. a.

Fits & types of fits.

Fits: When 2 parts are to be assembled, the relation resulting from the difference between their sizes before assembly is called a fit. Depending upon the actual limits of hole or shaft, the fit may be clearance fit, or a transition fit or an interference fit.

a) Clearance fit:

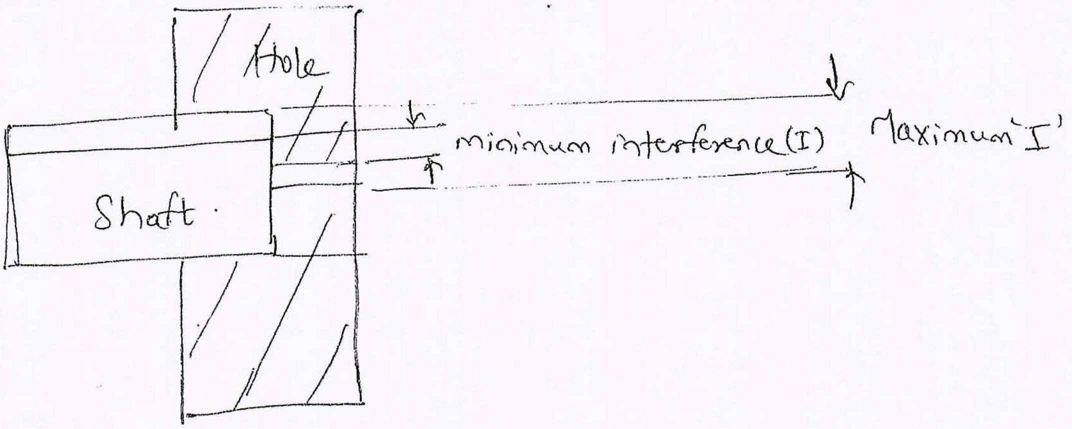


In this type of fit, the largest permitted shaft diameter is less than the smallest hole diameter so that the shaft can rotate or slide according to the purpose of assembly.

ex: pistons & crank case of IC engines,
slides of m/c tools

P.T.O.

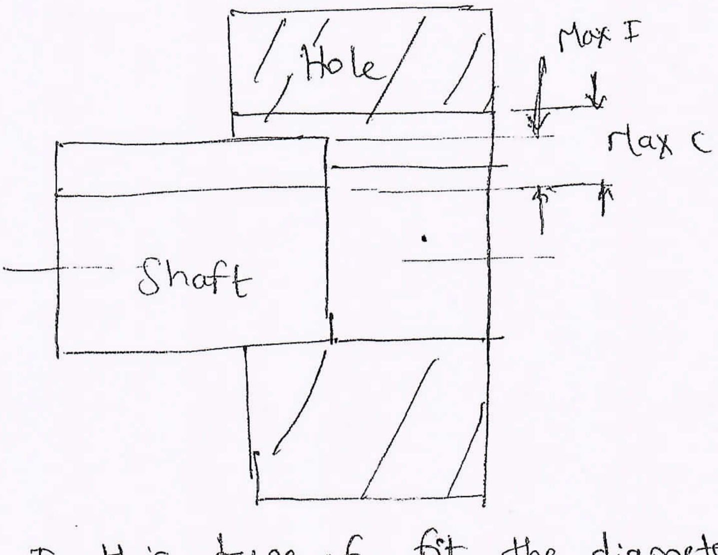
b) Interference fit:



In this type of fit, the minimum permitted diameter of the shaft is larger than the maximum allowable diameter of the hole: Here negative clearance exists b/w sizes of the hole & shaft.

ex: tool holder adaptors, bearing bushes

c) Transition fit:



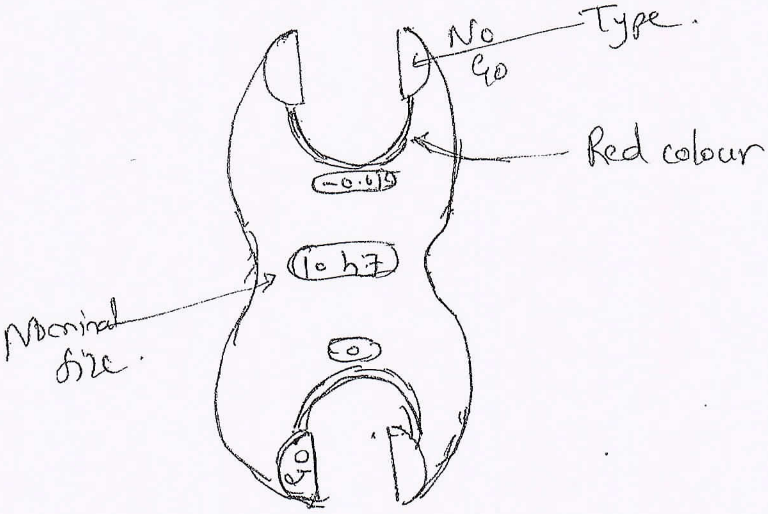
In this type of fit, the diameter of the largest allowable hole is greater than the smallest shaft, but smallest hole is smaller than the largest shaft such that, Q8.b. Limit system sets the maximum and minimum allowable dimensions for component. The component has to be manufactured within the specification of said limit. ex: Shaft of size $\phi 20 \pm 0.1$ mm. Maximum limit = 20.1 mm, minimum limit = 19.9 mm.

The limit system ensures that when multiple parts are manufactured (in mass production) [Also the constituent parts may be manufactured at different points/ locations], when the parts are assembled, they fit together correctly by controlling the tolerances within specified range. Thus it enables interchangeability and proper functioning of the product. The limit system dictates, how much variation is acceptable in a part's size during manufacturing to maintain functionality. It also fecilitates fast inspection of parts by limit gauging. In limit gauging, the component size is checked to fall within the defined limits using 'Go' and 'No Go' gauges.

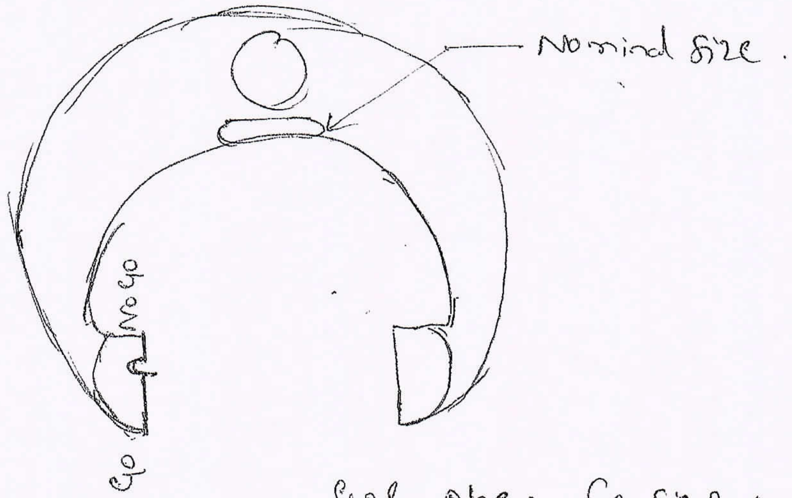
Q8.c Snap gauges:

Snap gauges are used to check external dimensions, thickness, diameters etc.

Rib types snap gauges:



Double ended snap gauges can be used for checking sizes for the range of 3mm to 100mm & single ended progressive type snap gauges are suitable for sizes 100 to 250mm. The gauging surfaces of snap gauges are hardened upto 720 to 750 HV (58-60 HRC) & are suitably stabilised, ground & lapped.



Go & NoGo for sizes over 100mm & upto 25

Q9. a. **Taylor's Principle**

'Go' & 'No Go' gauges should be designed to check maximum and minimum material limits which are checked as below.

'Go' Limit. This designation is applied to that limit of the 2 limits of size which corresponds to the maximum material limit considerations, i.e, upper limit of a shaft & lower limit of a hole.

The form of the 'Go' gauge should be such that it can check one feature of the component in one pass.

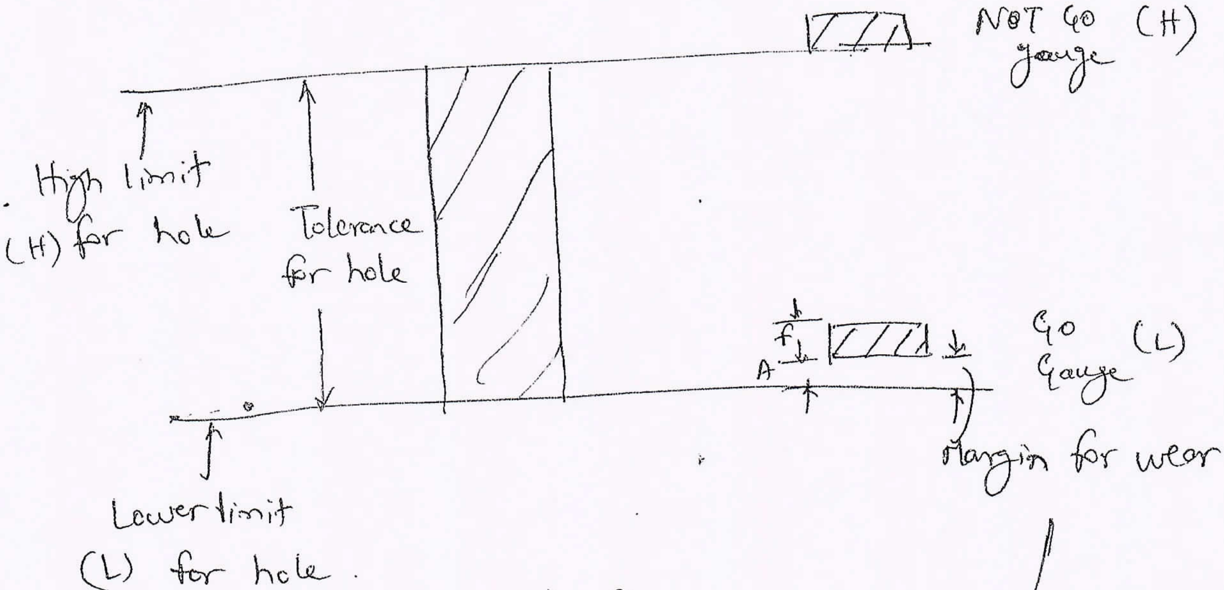
'No Go' Limit. This designation is applied to that limit of the two limits of size which corresponds to the minimum material condition, i.e, the lower limit of a shaft & upper limit of a hole.

'No Go' gauge should check only one part or feature of the component at a time, so that specific discrepancies in shape or size can be detected. Hence a separate 'No Go' gauge is required for each different individual dimension.

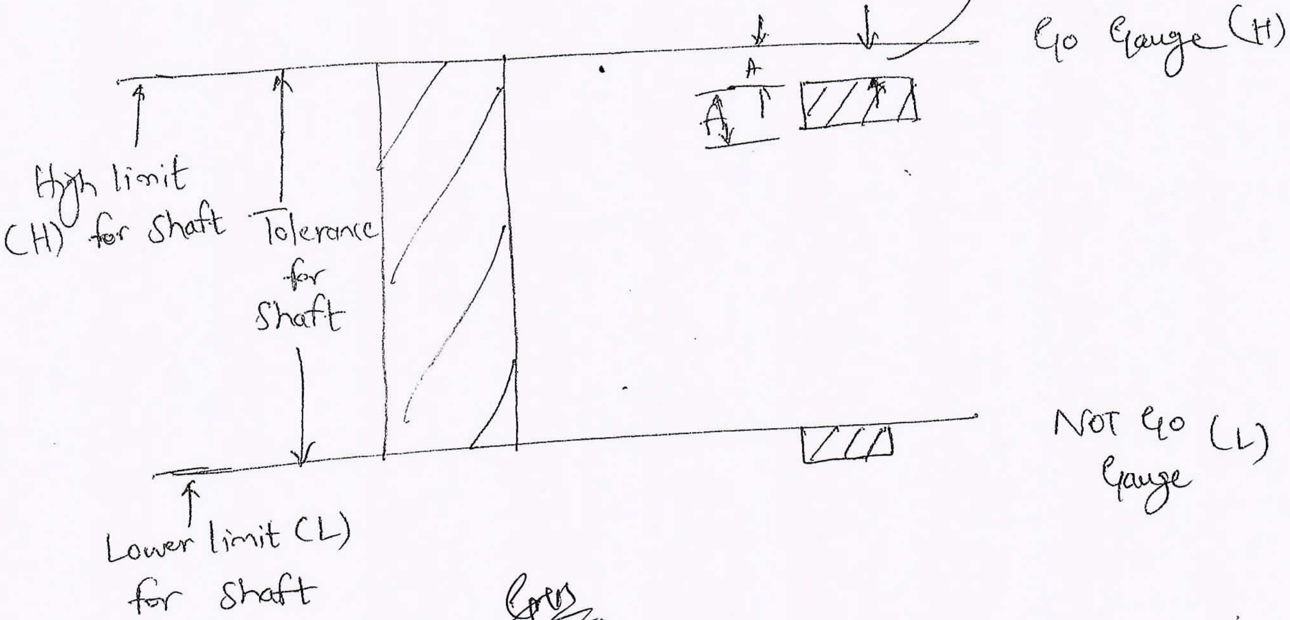
In the new system of gauge design, following principles are followed along with Taylor's principle.

1) Tolerance should be as wide as is consistent with satisfactory functioning, economical production & inspection.

2) No work should be accepted which lies outside the drawing specified limits.

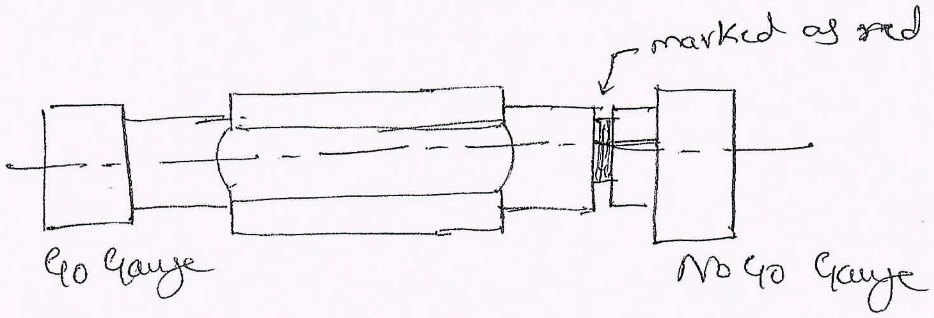


(a) Plug gauges



Q9.b. Types of Gauges :

Plain plug gauges:



Plain plug gauges are used for checking sizes of holes. Gauging members of the plain plug gauges are made of suitable wear resisting steel and the handles can be made of any suitable steel or aluminium. The gauging surfaces are normally hardended to 750 H.V. or 60 HRC, & suitably stabilised & ground & lapped.

Various types of plug gauges are:

i) Plug gauges for size upto 10 mm (solid type),

ii) " " " " over 10 mm to 30 mm (taper inserted type)

iii) " " " " 30 to 63 mm (fastened type)

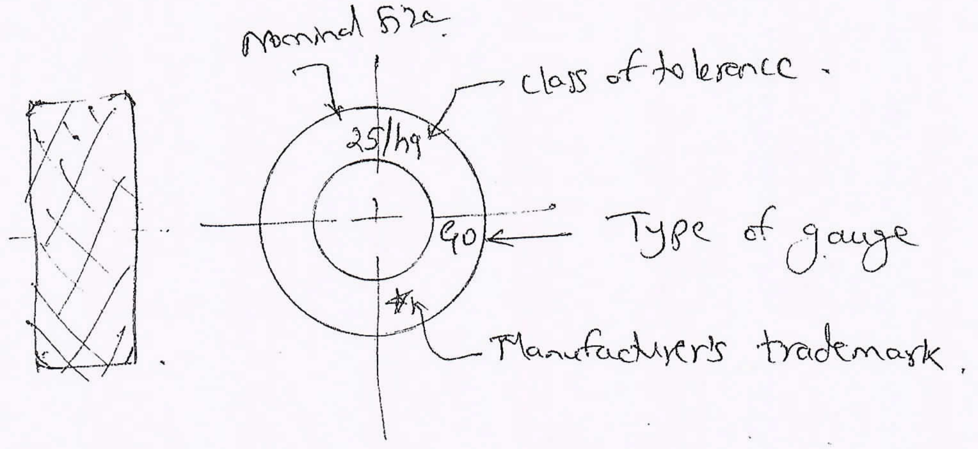
iv) " " " " " 63 to 100 mm (" ")

v) " " " over 100 to 250 mm (flat ")

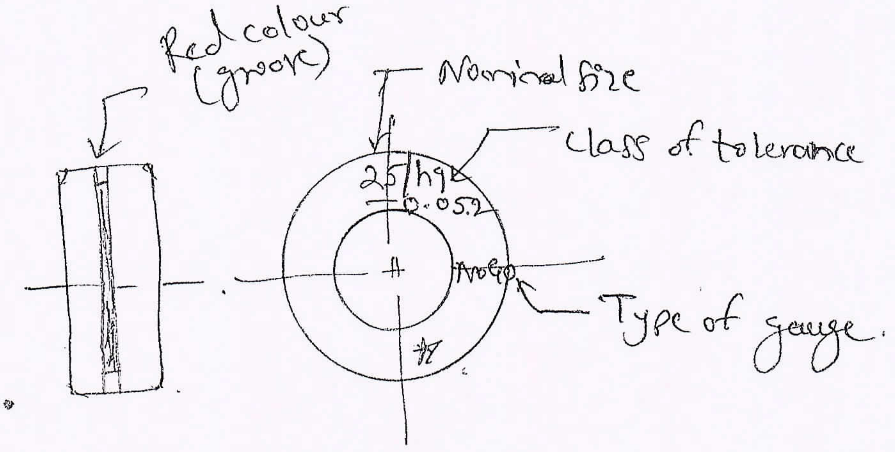
Cont

Ring gauges:

a)



b)



Plain ring gauges are made of suitable wear resisting steel & the gauging surfaces are hardened to hardness of about 720/770 HV. [58-60 HRC] They are made to undergo suitable heat treatment process & then ground & lapped. Ring gauges are used to check the external diameters of shafts.

Q9. C. Different types of gauge tolerances.

1) According to type:
   a) Standard gauge tolerance
   b) limit gauge "

2) According to purpose
   a) workshop gauge tolerance
   b) inspection " "

3) Reference or master gauge tolerances

4) According to design
   a) Single limit & double limit gauge tolerances
   b) Sing ended & double ended gauge tolerances
   c) Fixed gauge tolerances & adjustable gauge tolerances.

5) others : Profile gauge tolerances

Q10.a. Characteristics of comparators:

1) The instrument must be of robust design & construction so as to withstand the effect of ordinary usage without impairing its measuring accuracy.

2) The indicating device must be such that readings are obtained in least possible time and for this, magnification system used should be such that the readings are dead beat.

3) Provision must be made for maximum compensation for temperature effects

4) The scale must be linear & must have straightline characteristic

5) Indicator should be constant in it return to zero.

6) Instrument, though very sensitive, must withstand a reasonable ill usage without permanent harm.

7) Instrument must have maximum versatality, i.e, its design must be such that it can be used for a wide range of operations.

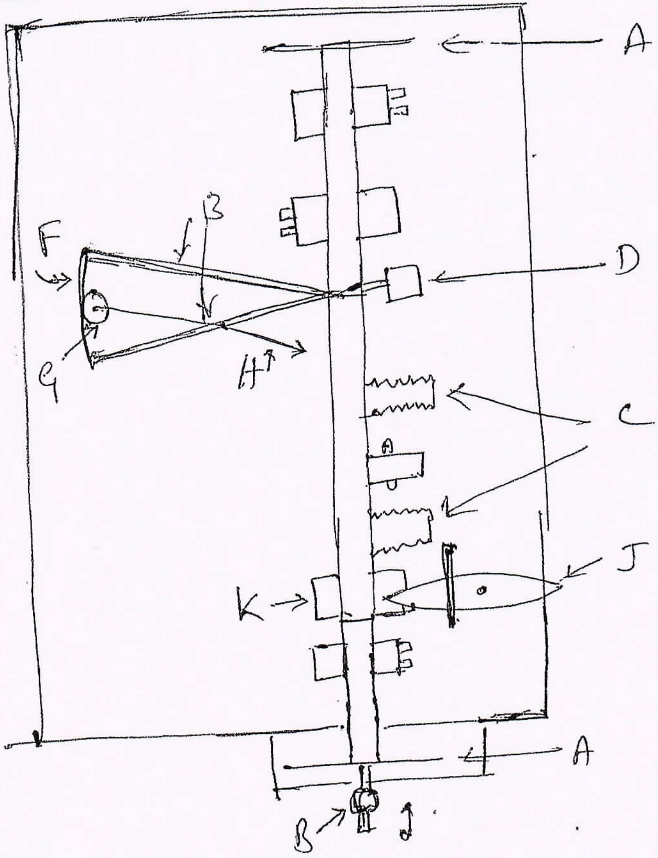
8) Measuring pressure should be low & constant.

Classification of comparators:

According to the principles used for obtaining Suitable degrees of magnification of the indicating device relative to the change in the dimension being measured, the various comparators may be classified as follows:

1) Mechanical comparators
2) Mechanical-optical comparators.
3) Electrical & electronic comparators
4) Pneumatic comparators.
5.) Fluid displacement comparators
6) Projection comparators
7) Multicheck comparators
8) Automatic gauging machines.

Q10b. Sigma Comparator:



It is a mechanical comparator. Constructional details are as shown in the figure. The vertical beam is mounted on flat steel springs 'A' connected to fixed members, which inturn are screwed to back plate. The assembly provides a frictionless movement with a restraint from the springs. The shank 'B' at the base of the vertical beam is arranged to take a measurin contact, selecting from the available range. The stop 'C' is provided to restrict movement at the lower extremity of the scale.

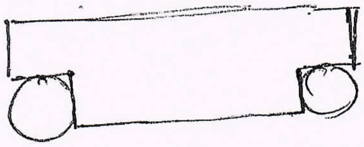
Mounted on the fixed members, is the hinged assembly 'D' carrying the forked arms 'E". This assembly incorporates a hardened fulcrum operative on the face of a jewelled insert on the flexible portion of the assembly.

The metal ribbon F, attached to the forked arms, passes around the spindle 'G" causing it to rotate in specially designed miniature ball bearings. The indicating pointer H is secured to boss on the disc. The trigger 'J' is used to protect the measuring conta

The instrument is available with vertical capacities (150 mm to 600 mm) & magnifications (500 to 5000).

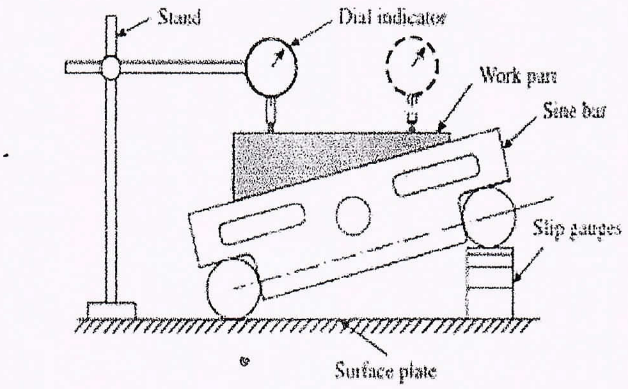
Sine bars:

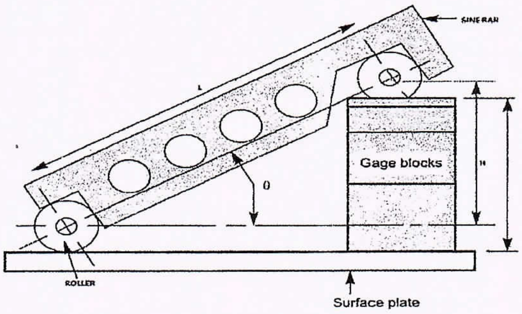
It is an instrument, which utilizes the high degree of precision available for linear measurement in the form of slip gauges can be ~~utilised~~ for the measurement of angles with usage of slip gauges. Sine bar consists of lapped steel bar at each end of which is attached an accurate cylinder, the axes of cylinders being mutually parallel and parallel to upper surface of bar. The axes are separated by a nominal distance usually 100mm or 250mm for metric bars and 5 or 10 inches (for those in inch units)



If the cylinders or rollers are stood on a surface plate, the surface of the bar will be parallel to the plate. If pile of slip gauges is placed under one roller, the bar

Surface will lie at an angle to the surface plate and in order to set the bar at a specified Lle the slips required will have a value equal to the distance between the rollers multiplied by the sine angle.





(Gurunath Menandi)

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