FREDY A. LUYENGE

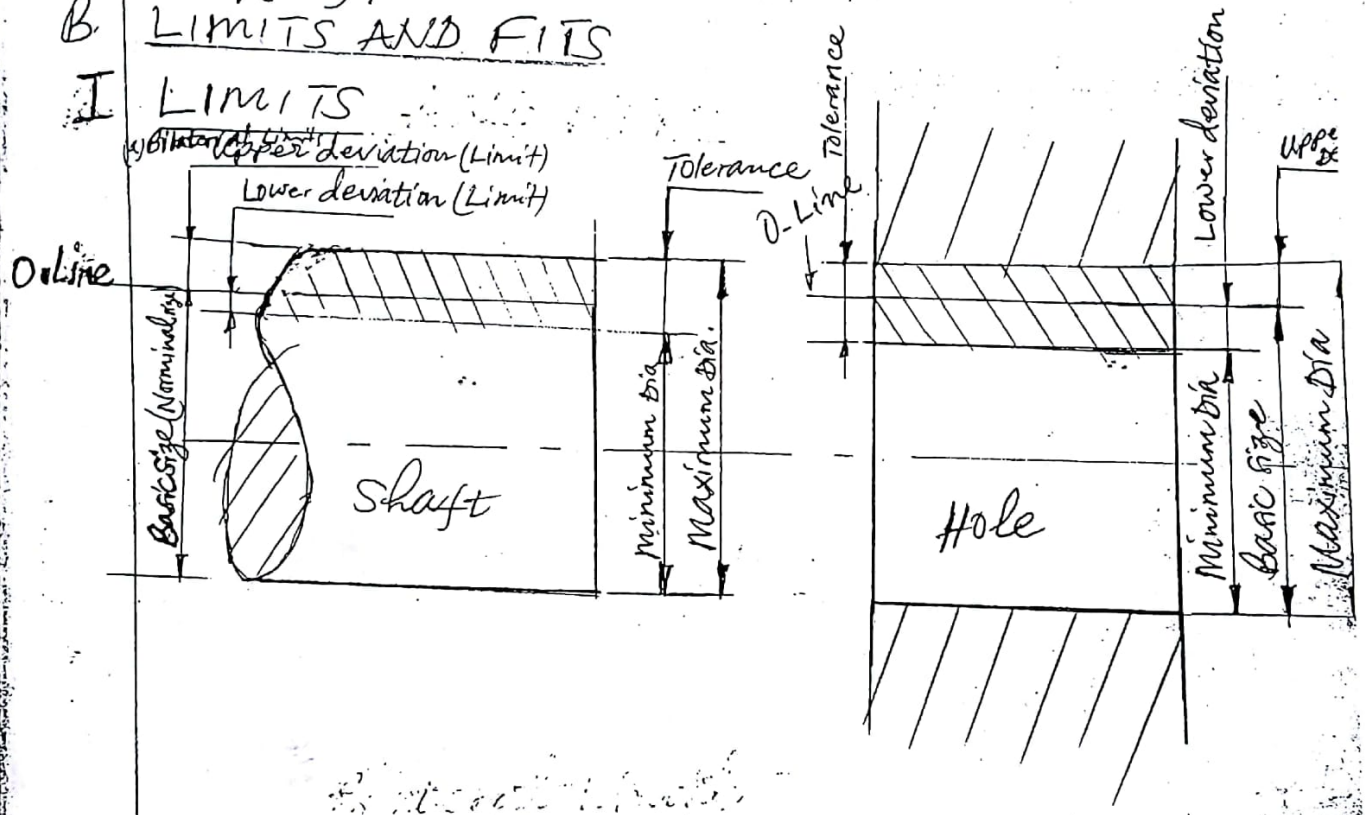
INTERCHANGEABILITY, LIMITS AND FITS

A. INTERCHANGEABILITY

Interchangeability is a system of standardised components (eg bearing) will assemble correctly with any mating component (eg axle).

B. LIMITS AND FITS

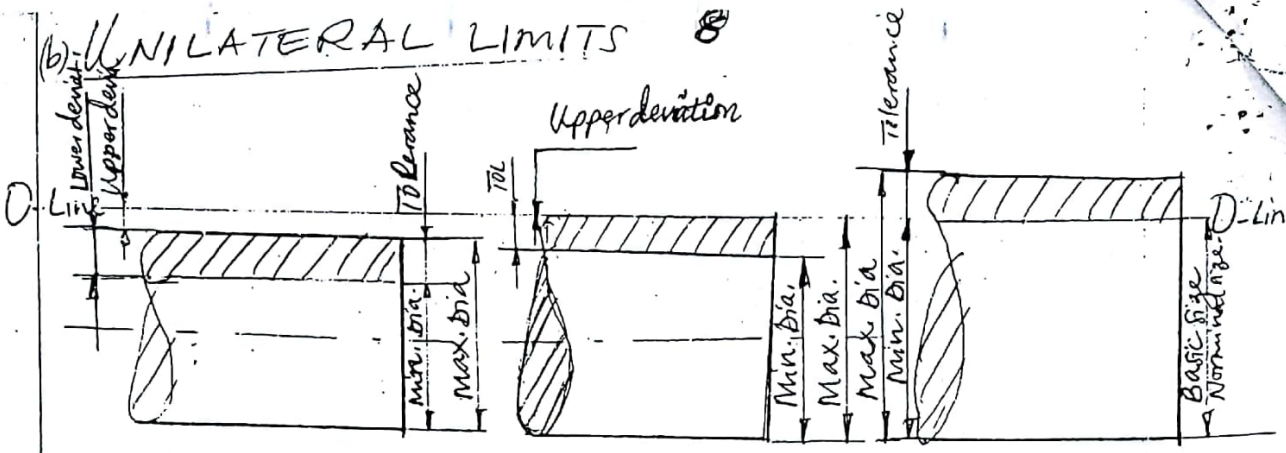
I. LIMITS



eg Basic (Nominal) size — 50 mm
Upper deviation — +0.023 mm
Lower deviation — −0.007 mm
Maximum diameter — 50.023 mm
Minimum diameter — 49.993 mm
Tolerance — 0.03 mm (0.023 + 0.007)

Actual size: Real size of Ø after machining may be 50.01mm, 49.99mm etc

(b). UNILATERAL LIMITS



Depending on its location to the Basic (nominal) size (O-Line) the different limits are named

at the shaft from a — z

at the Hole from A — Z

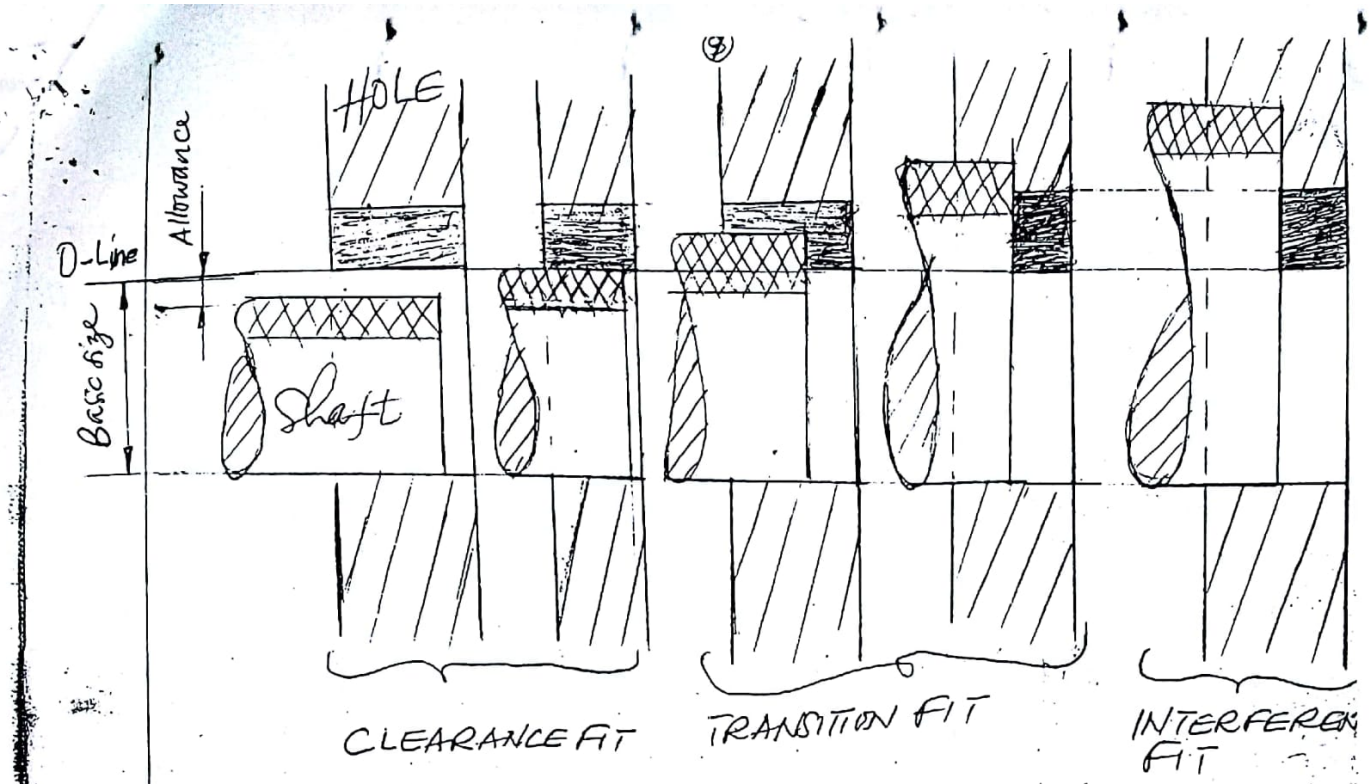
II FITS

Allowance = The difference between max. dia of the shaft and minimum Dia of the Hole.

+ ve allowance means clearance fit

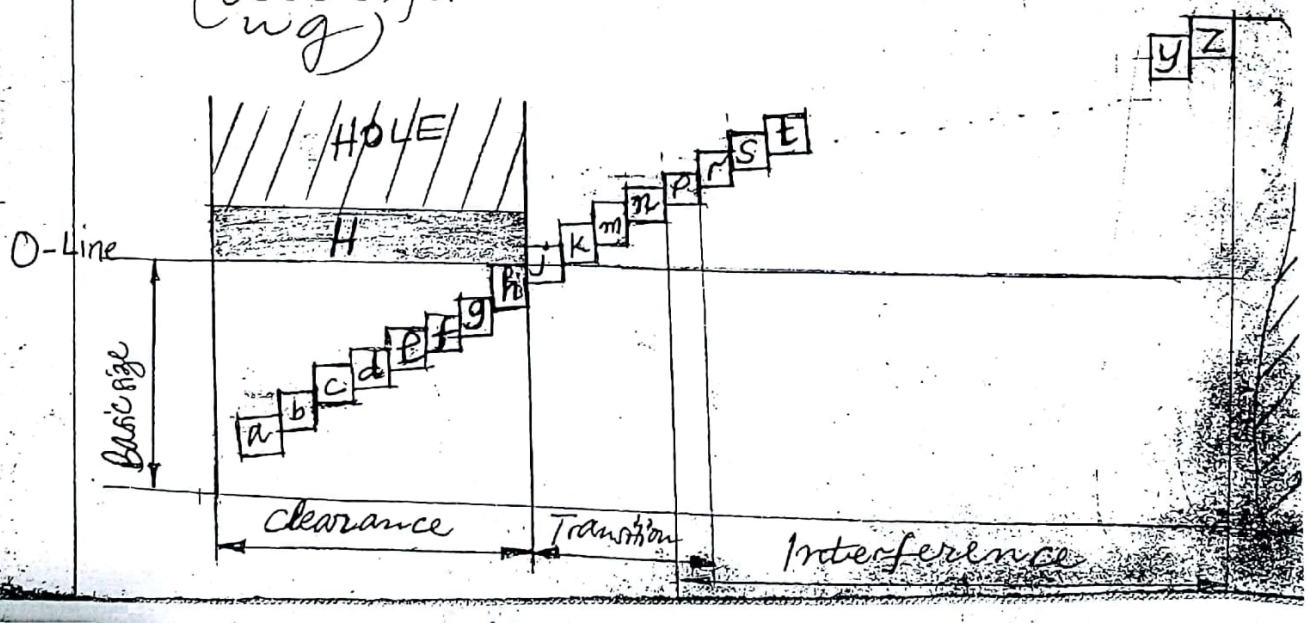
− ve allowance means Interference or Transition.

Allowance = Min. Hole ϕ − Max. Shaft ϕ



(a) HOLE BASIS SYSTEM

All holes have the same ~~limit~~ (fixed limit) which is called "H".
The different fits are produced by varying the limits of the shaft from a - z.
(Used for machine and locomotive building)

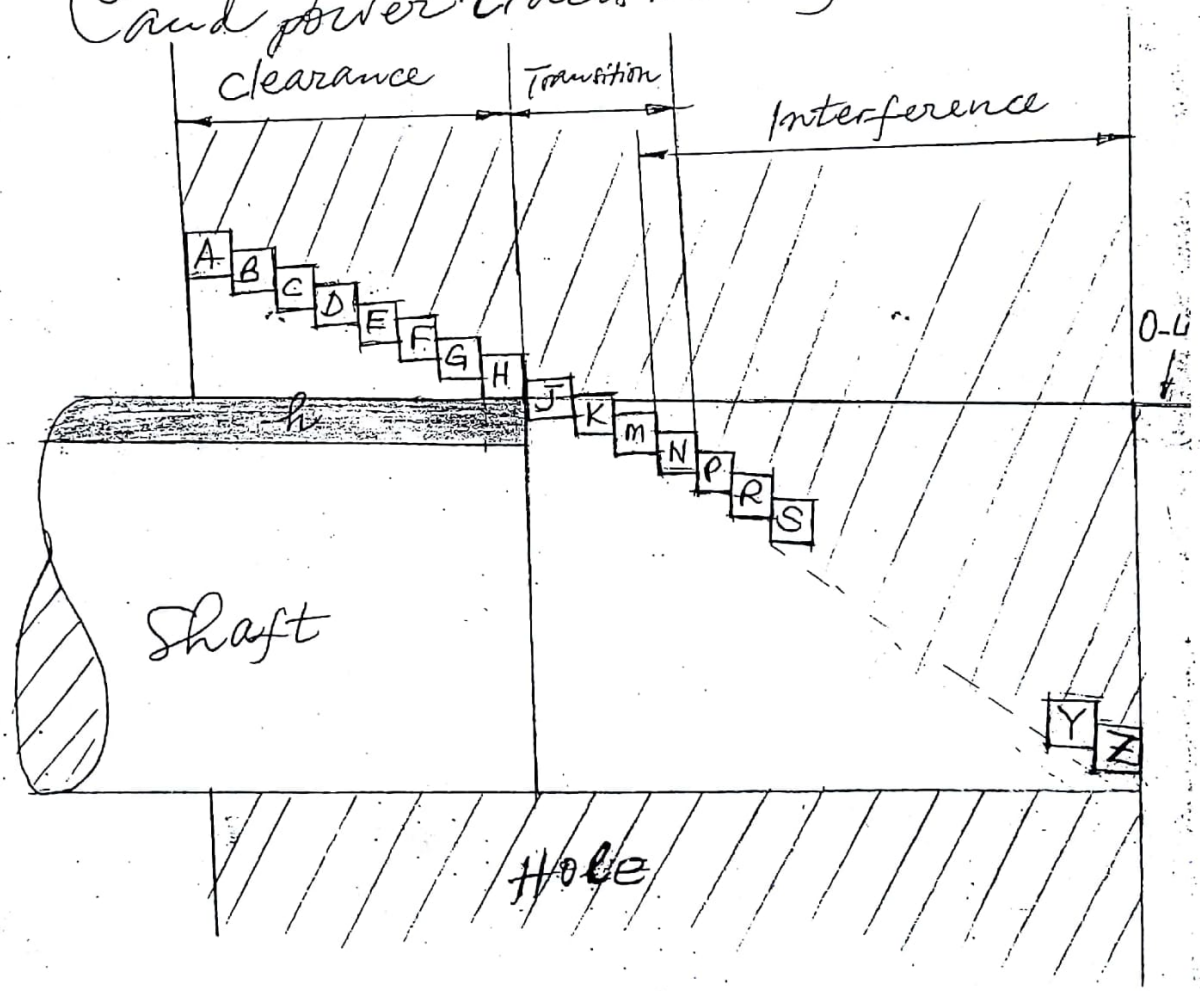


(b) SHAFT BASIS SYSTEM

All shaft diameter have the same class of limit (fixed limit) which is called "h".

The different fits are produced by varrying the limits of the hole from A – Z

(Used for electric motors, ball bearing and power transmission)



III QUALITY OF LIMITS AND FITS OR ISO GRADE OF TOLERANCES

There are 18 quality of ~~limits~~ and fits or grades of tolerances namely 01, 0, 1, 2, 3, 4, 5, ... 15, 16.

The higher the number the larger the tolerance is.

(a) Close limits = small tolerances
- Good control of fits is possible but production is expensive.
- Grades 01, 0, 1 .... 4 are for precision instruments.

(b) Wide limits = Larger tolerances
- Less accuracy when mating parts together. Cheap production.
- Grades 5, 6, 7 .... 11 are for general workshop practice.
- Grades 12, 13, 14 ... 16 are for pressed and rolled products.

- To dimension a hole or a shaft according to the limits and fits we need:
  ① The Basic (Nominal) size

⑥ ⑫

② Class of limit (fit) required (eg A–ZC)
③ Quality of the production (from (01, 0, 1 ..... 16)

eg ⓐ Hole

50H7, $(\phi 50^{+0.025}_{-0.000})$
15K7 $(\phi 15^{+0.006}_{-0.012})$
30E9 $(\phi 30^{+0.092}_{+0.040})$
45P9 $(\phi 45^{-0.026}_{-0.088})$

ⓑ Shaft

17js6 $(\phi 17^{+0.0055}_{-0.0055} = \phi 17^{\pm 0.0055})$
30js5 $(\phi 30^{+0.0045}_{-0.0045} = \phi 30^{\pm 0.0045})$
30h9 $(\phi 30^{-0.065}_{-0.117})$
45k6 $(\phi 45^{+0.018}_{+0.002})$

(c) HOLE + SHAFT (HOLE & SHAFT FIXED TOGETHER)

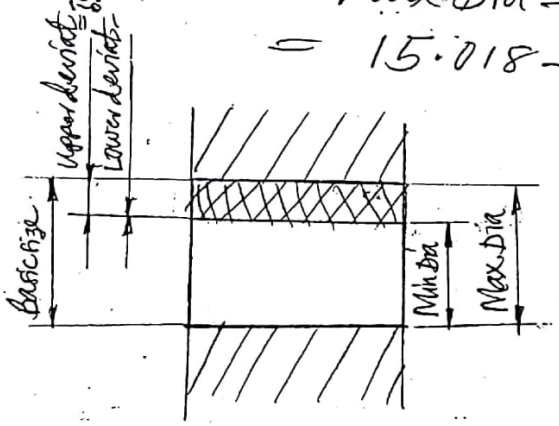
$75\frac{H7}{d10}$ (Clearance fit) $16\frac{H7}{h6}$ (Clearance fit) $48\frac{H8}{m6}$ (Transition fit)

Theoretically all classes of limits and quality ranges are possible. But in most cases we use only classes and ranges given in Appendix 3 pg 390 & 391 HAPMAN – WORKSHOP TECHNOLOGY PART 2

To find Tolerances and Fits

(i) $15 H7 \left(\phi 15^{+0.018}_{-0.000}\right)$

Basic (nominal) size = 15 mm
Upper deviation (limit) = 0.018 mm
(ud)
Lower deviation (Ld) = 0.000 mm
Maximum diameter (High limit) = 15.018 mm
Minimum diameter (Low limit) = 15 mm.
Tolerance = max. dia − min. dia.
= 15.018 − 15.0 = 0.018 mm.



(ii) $95 k6 \left(\phi 95^{+0.025}_{+0.003}\right)$

Basic size = 95 mm
Upper deviation (ud) = 0.025 mm
Lower deviation Ld = 0.003 mm
Max. dia. = 95.025 mm
min. dia. = 95.003 mm
Tolerance (TOL) = 95.025 − 95.003 = 0.022

(8) (14)

	$15 d_{10} \left(\phi 15^{-0.050}_{-0.120}\right)$	$50 h_6 \left(\phi 50^{+0.000}_{-0.016}\right)$
Basic size	15 mm	50 mm
Upper deviation	−0.050 mm	0.000 mm
Lower deviation	−0.120 mm	−0.016 mm
Max. Dia.	14.95 mm	50.00 mm
Min. Dia.	14.88 mm	49.984 mm
Tolerance	0.07 mm	0.016 mm

	36 H9	7 c11	230 k6	84 f7	16 n6
Basic size	36	7	230	84	
Upper deviation	0.062	−0.080	0.033	−0.036	
Lower deviation	0	−0.170	0.004	−0.071	
Max. Dia	36.062	6.920	230.033	83.964	
Min. Dia	36	6.830	230.004	83.929	
Tolerance	0.062	0.090	0.029	0.035	

$30 \frac{H9}{e8}$

	Hole	shaft
	$\phi 30^{+0.052}_{+0.000}$	$\phi 30^{-0.040}_{-0.073}$
Max. Dia	30.052	29.996
Min. Dia.	30.000	29.927
Allowance	30.0 − 29.996 = 0.004	
Fit	Clearance	

(9) (15)

$100 \frac{H7}{n6}$

	Hole	shaft
	$100^{+0.035}_{+0.000}$	$100^{+0.045}_{+0.023}$
Max. Dia.	100.035	100.045
Min. Dia	100.000	100.023
Allowance	100.0 − 100.045 = −0.045	
Fit	Transition (Read chart)	

$72 \frac{H7}{p6}$

Hole

$72^{+0.030}_{+0.}$

Max Dia = 72.030

Min. Dia = 72.0

Shaft

$72^{+0.051}_{+0.032}$

Max. Dia = 72.051

Min. Dia = 72.032

Allowance = 72.0 − 72.051 = −0.051

Fit = Interference (Read chart)

Home work

①

		$18 \frac{H7}{h6}$	$193 \frac{H7}{k6}$	$65 \frac{H8}{f7}$	$46 \frac{H7}{s6}$
HOLE	Max. Dia				
	Min Dia				
SHAFT	Max. Dia				
	Min. Dia				
Allowance					
Clearance fit					
Transition fit					
Interference fit					

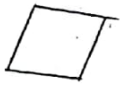
(10) (16)

(2) $40\ \frac{H7}{h6}$

Draw the shaft and the hole together and show the limits they are situated to the basic (nominal) size (0-line)

GEOMETRICAL TOLERANCES

Geometrical Tolerances of straightness, flatness, parallelism, squareness, angularity, concentricity, symmetry and position, are required to ensure that component parts are interchangeable for assembly and function.

	SYMBOL	CHARACTERISTIC/MEANING
(a) Form		
①	———	= Straightness
②		= Flatness
③		= Roundness
④		= Cylindricity
⑤		= Profile (line)
⑥		= Profile (surface)
(b) Attitude		
⑦	//	= Parallelism
⑧	⊥	= Squareness
⑨	∠	= Angularity
(c) Location		
⑩		= Position
⑪		= Concentricity
⑫	=	= Symmetry

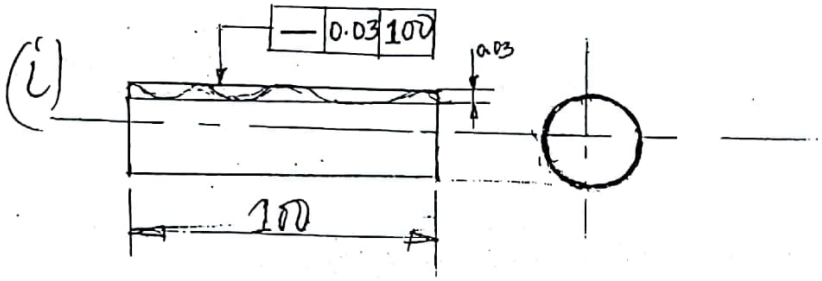
(d) Composite symbol characteristics / tolerancing

= Run out

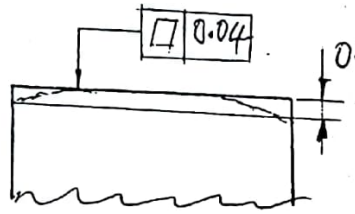
Ⓜ = Maximum material condition or MMC

□ = Boxed dimension (True position)

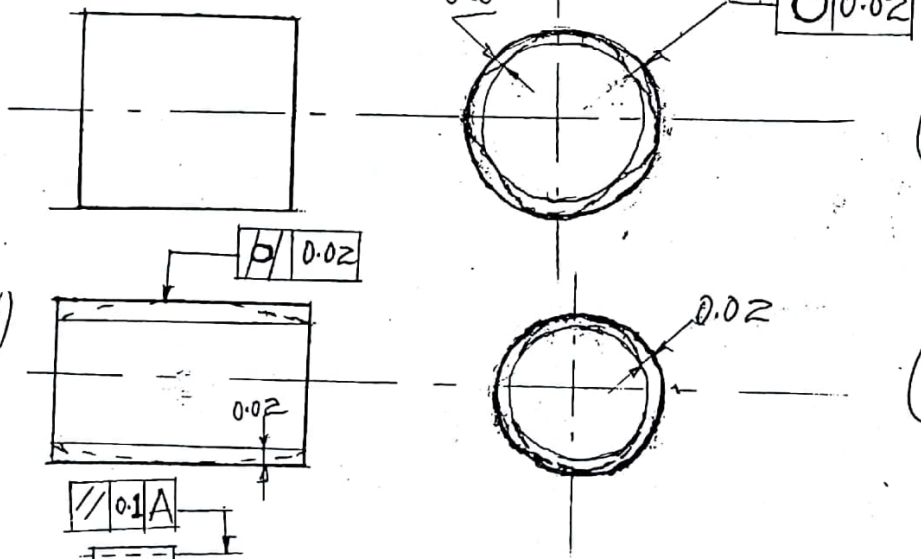
Examples.

(i) 

(Straightness TOL 0.03)

(ii) 

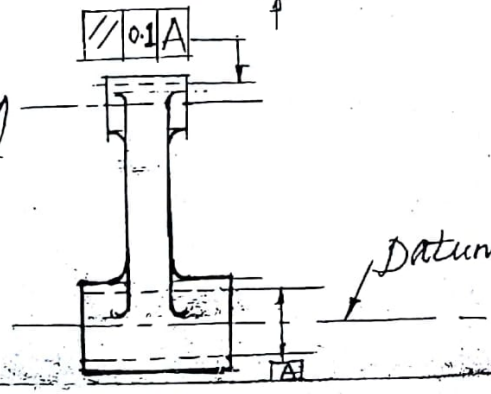
NOT CONCAVE (Flatness TOL 0.04)

(iii) 

(RD TOL 0.02)

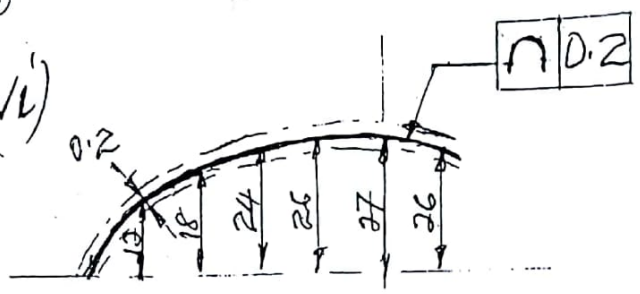
(CYL TOL 0.02)

(iv)

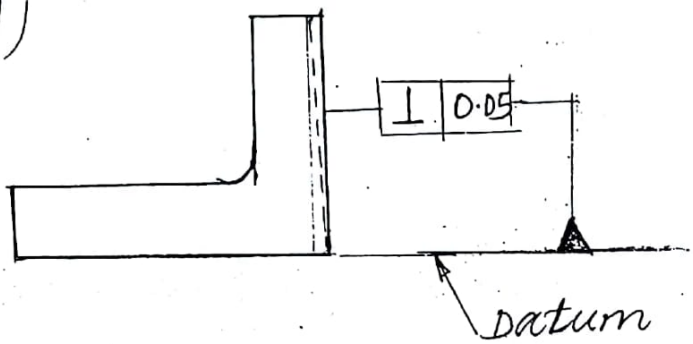
(v) 

(Para TOL 0.1)

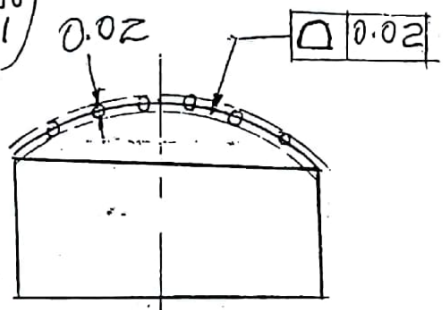
(3)

(vi) 

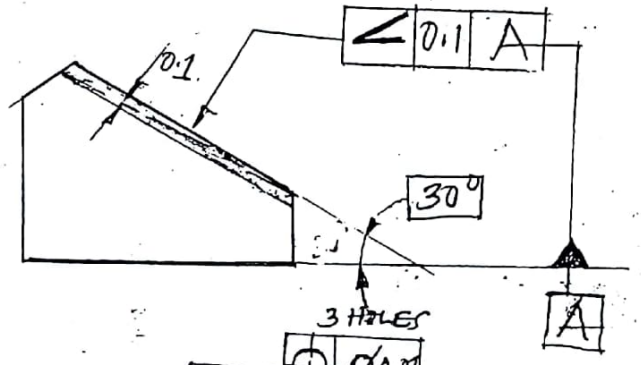
(Profile Tol (Line) = 0.2)

(vii) 

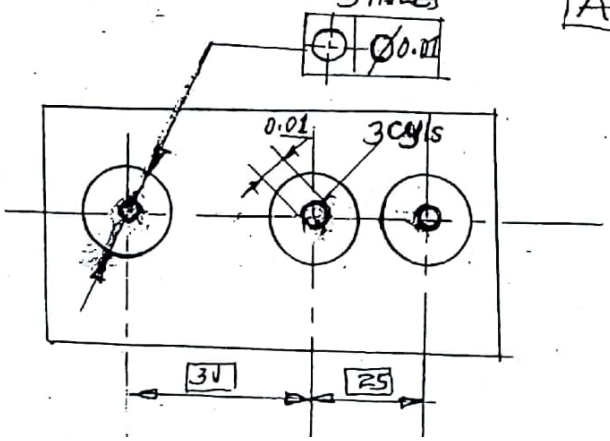
(Sq Tol 0.05)

(viii) 

(Profile Tol. 0.02 surface.)

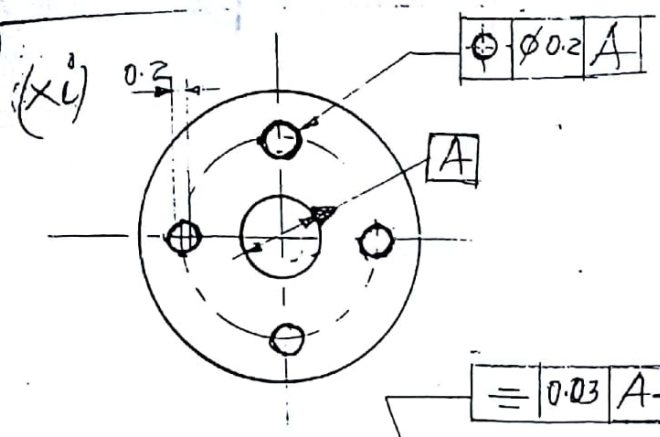
(ix) 

(Ang. Tol 0.1 Datum A)

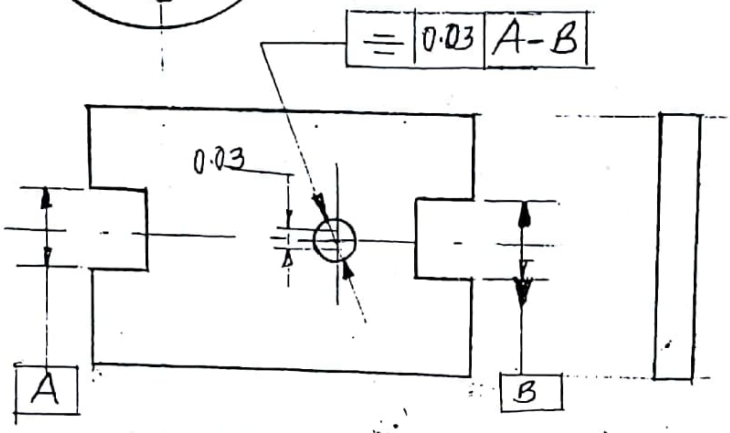
(x) 

(Posn Tol 0.01 3 HOLES)

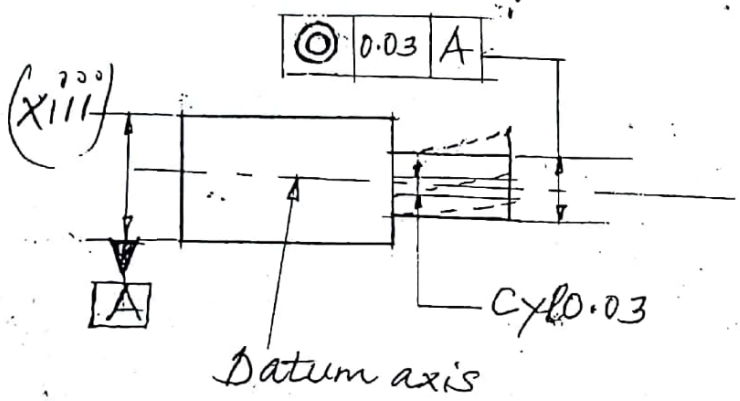
4)

(xi) 

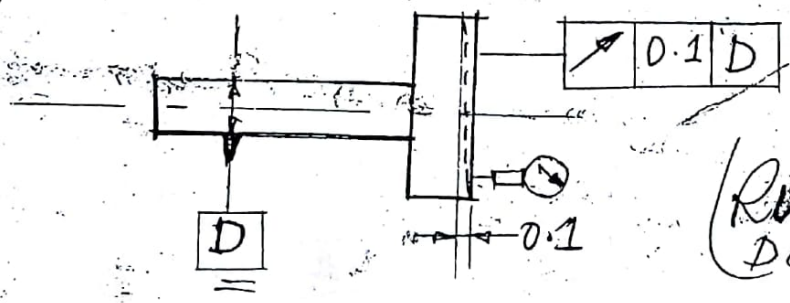
(Posn TOL 0.2 Dat A
4 Holes Ø0.2)

(xii) 

(SYM TOL 0.03
Datum A-B)

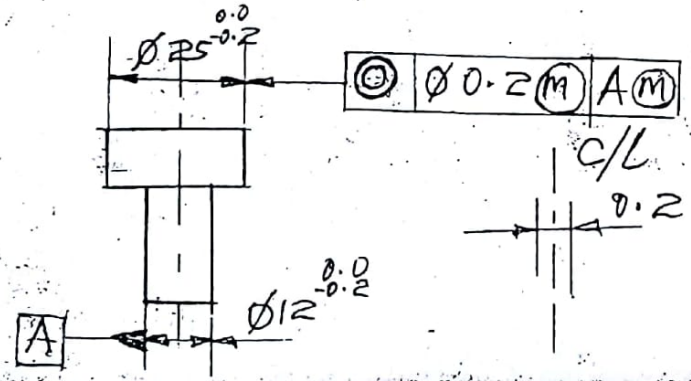
(xiii) 

(Conc. TOL 0.03
Datum A)

(xiv) 

(Run-Out TOL 0.1
Datum D)

Application



SURFACE ROUGHNESS

During machining operations accuracy of size and surface quality must be obtained.

Every surface is composed of minute hills and valleys known as Roughness (irregularities) which can be checked by means of a surface meter (stylus instrument). Irregularities are caused by the rate of metal removal (feed), characteristic of the cutting tool, etc.

A — Very rough
B — Rough
C — Smooth
D — Very smooth

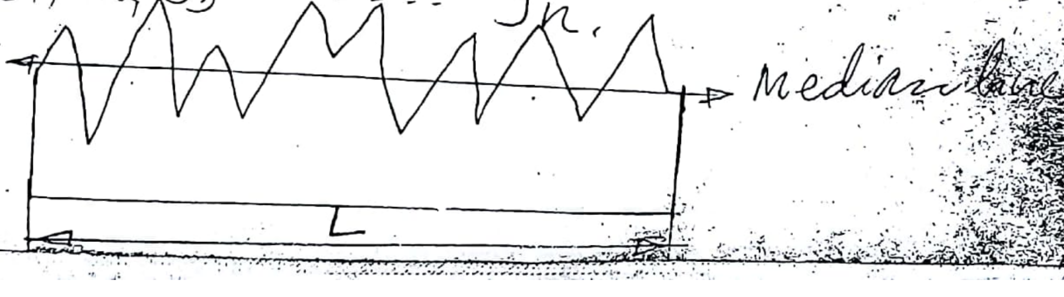
NB: Rougher surfaces greater friction, greater wear (for rotating revolving parts)

Irregularities are measured in micro (μ)

$1\mu = \frac{1}{1000}$ mm $= 10^{-3}$ mm $= 10^{-6}$ m.

The surface roughness is specified by refering to centre line average CLA or Mean square ~~Root~~ Average (Rms)

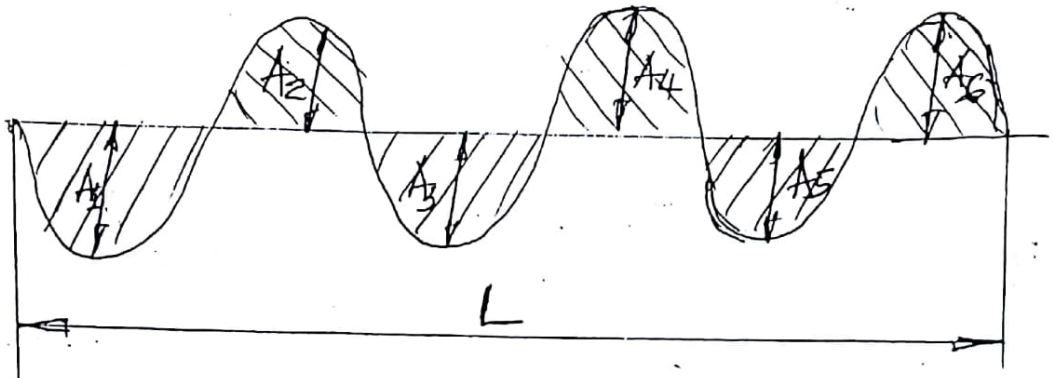
The average deviation of Irregularities (Ra) represents the average value of the deviation of the effective profiles $y_1, y_2, y_3 \ldots\ldots y_n$.



Long LG, True position TP, Assembly ASSY, Minimum - MIN, Maximum,
Cylinder CYL, External EXT,

$$Ra = \frac{1}{L}\int_0^L y\,dx = \sum_{1}^{n}\left(\frac{y_i}{n}\right) \quad (\mu m) \quad \text{②}$$

or



$$Ra = \frac{A_1 + A_2 + A_3 + A_4 + \cdots A_n}{L}$$

$$= \sum_{n=1}^{n=\infty} \frac{A}{L} \quad (\mu m)$$

SYMBOLS FOR INDICATING SURFACE ROUGHNESS Ra.

✓ – No information whether a cutting or non cutting process should be done.

✓ – Cutting process should be done.

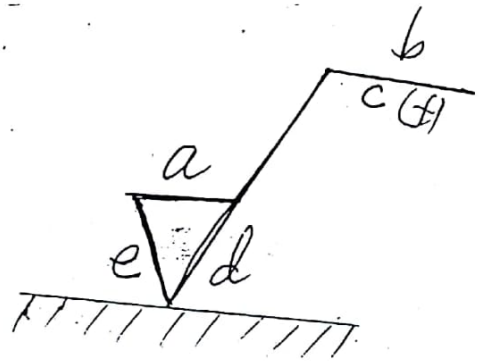
✓ – Cutting process is not allowed.

SYMBOL			Meaning
Cutting process is			
Optional	compulsory	not allowed	
N8 / or 3.2	N8 / or 3.2	N8 / or 3.2	Surface with max. roughness of Ra N8 or 3.2 µm resp.
N9 N7 / or 2.5 1.6	N9 N7 / or 5.3 1.6	N9 N7 / or 6.3 1.6	Surface with max. roughness of Ra N9 or 6.3 µm and min roughness of Ra of N7 or 1.3 µm.

Micrometre	50	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.			
Roughness Number													

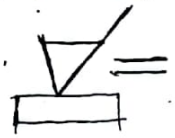
Micrometre	50	25	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.05	0.025
Roughness Number	N12	N11	N10	N9	N8	N7	N6	N5	N4	N3	N2	N1

Symbols for supplimentary informations



a – Roughness class N_1 – N12 or Ra in µmm,
b – Manufacturing process, treatment, coating etc.
c – Roughness width cut off (reference or sampling length)
d – Direction of Lay or score
e – machining allowance
f – Other indications of roughness (in bracket)

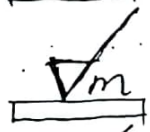
Symbol



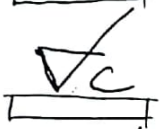
Parallel (Par) to plane.

Perpendicular (Perp.) to plane.

Crossed



multi day.

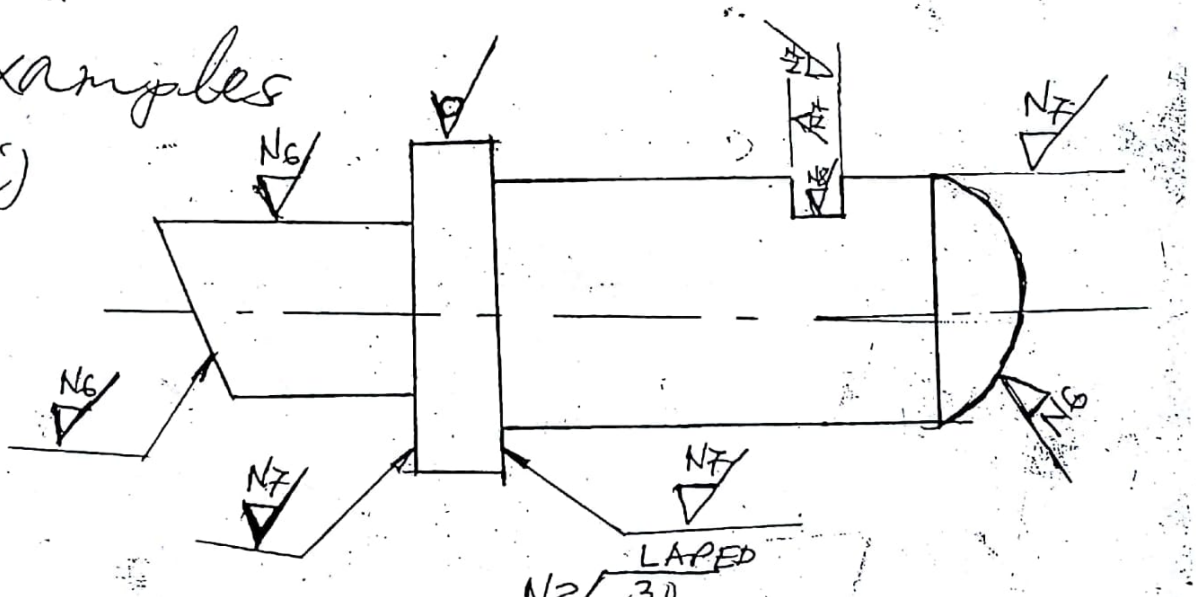


circular

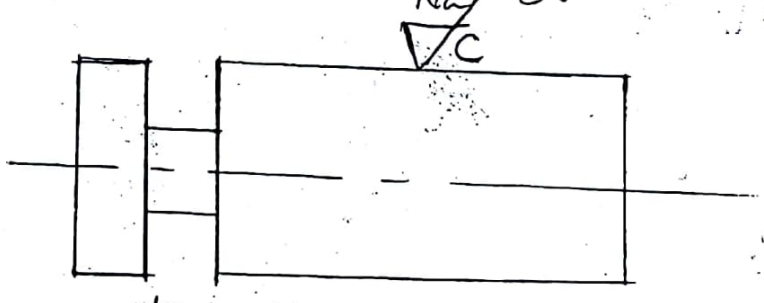
Radial

Examples

(i)

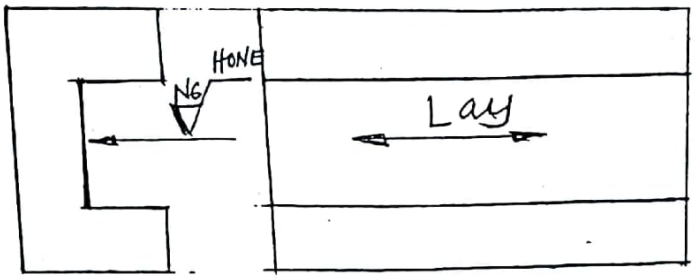


(ii)



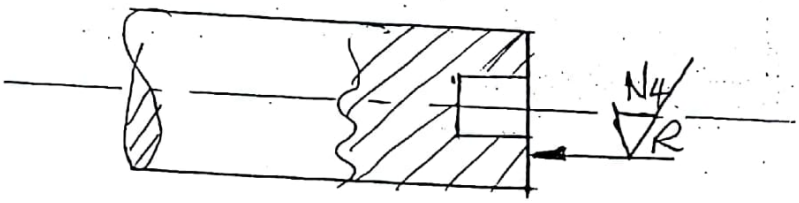
all over except as indicated.

(iii)

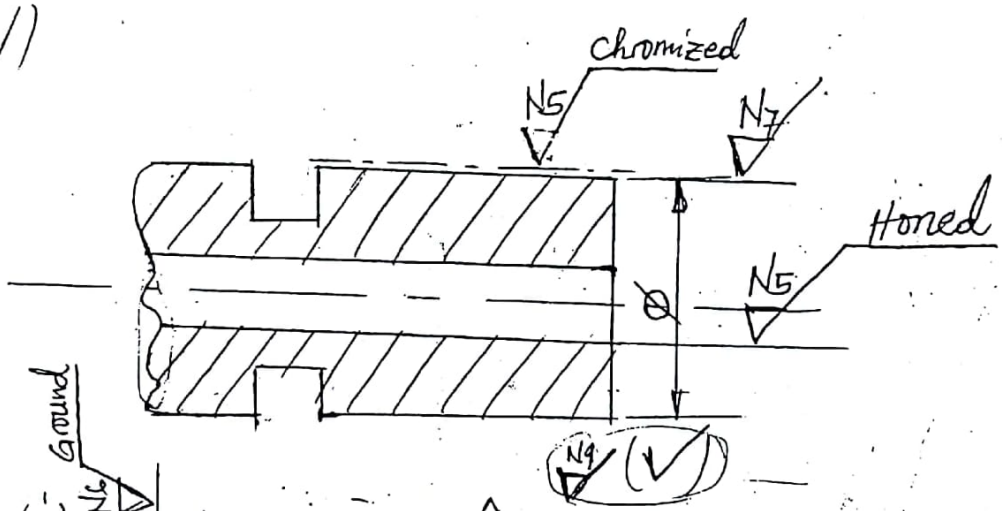


N8 all over except as indicated.

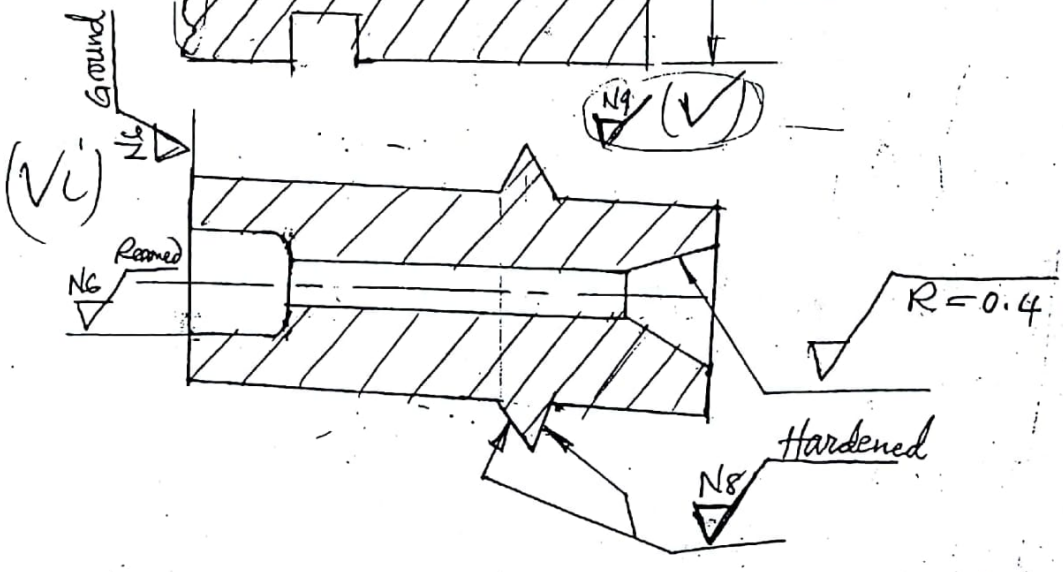
(iv)



(v)



(vi)



©

NB. For a given surface the symbol must be shown only once. & possible in the view where its dimension or its position is given.

eg

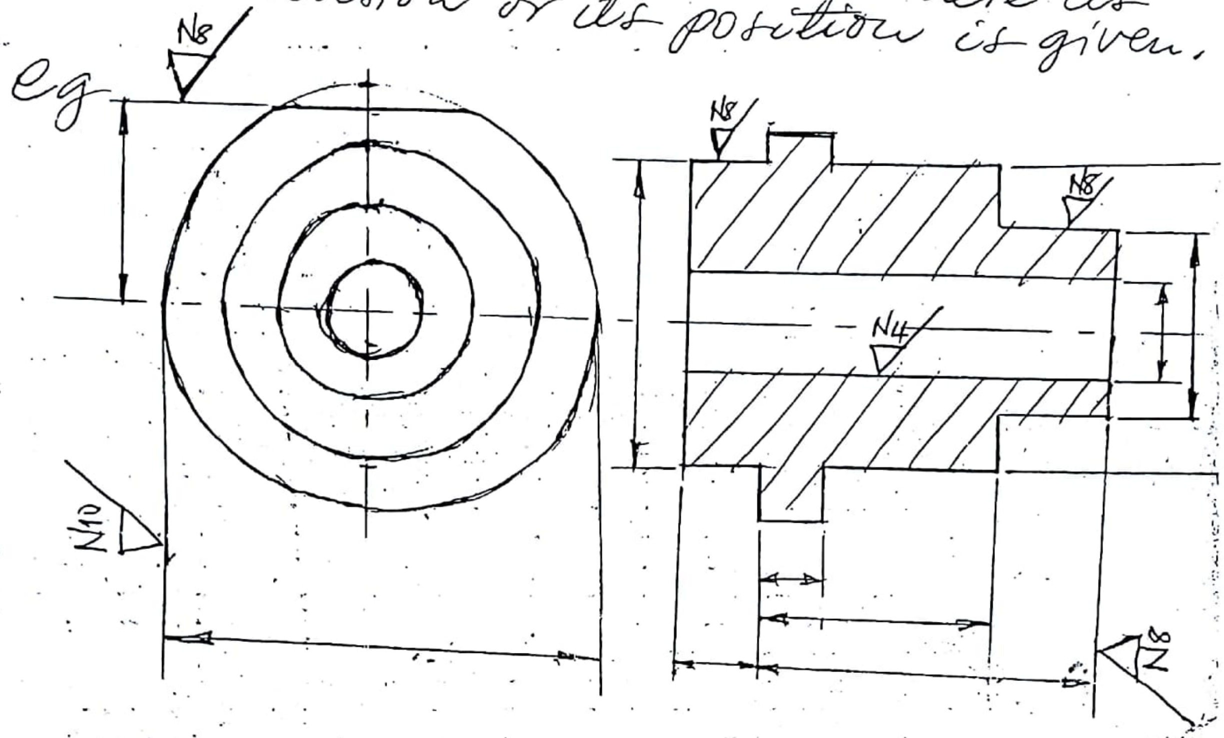


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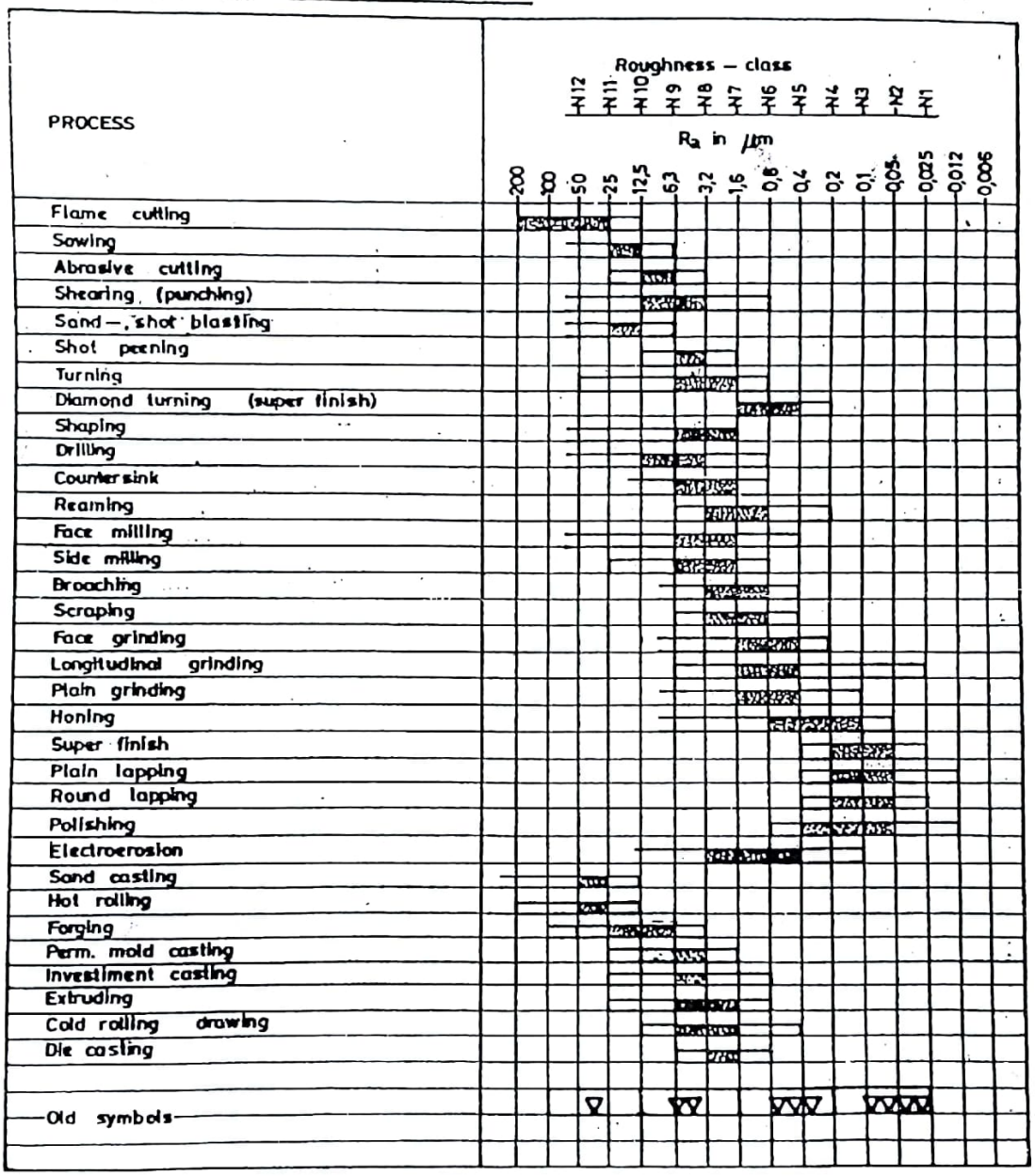
Table 90/1 : Attainable Roughness R_a



normal = roughness attainable with normal workshop practice.
fine = roughness attainable with special care or by using special methods.