

ME 1110 - Engineering Practice 1

Engineering Drawing and Design - Lecture 6

Representation of features Geometric tolerances

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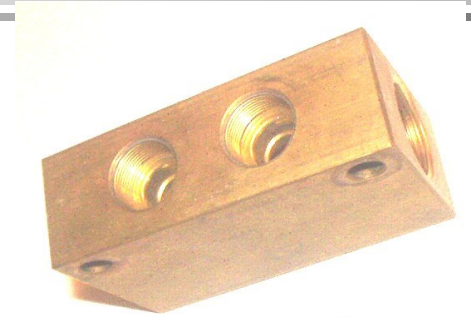
www.staff.city.ac.uk/~ra600/intro.htm

Objectives for today

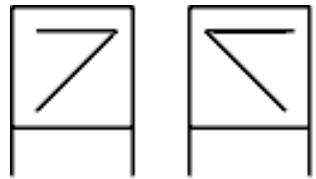
- How to represent standard engineering features
 - Gears; Bearings; Seals; Springs
 - Shafts, tubes; Fasteners
- What are tolerances and how are they specified
- Geometric tolerances
- Surface finish & machining

Exercise DrE-5 - Week 7

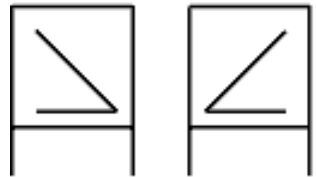
Parts to be
measured and drawn



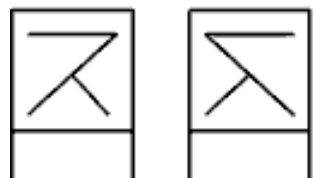
Representing standard features



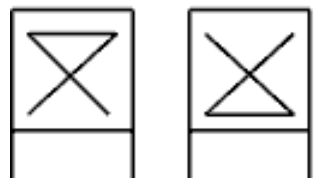
ROTATING SHAFT SEAL
WITHOUT DUST SEAL



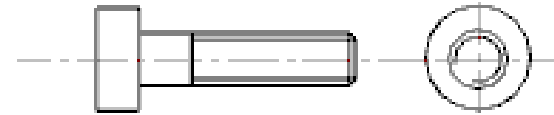
ROTATING HOUSING SEAL
WITHOUT DUST SEAL



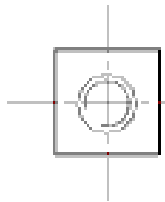
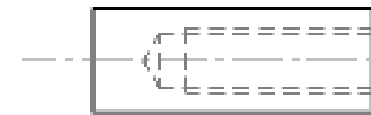
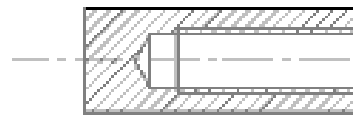
ROTATING SHAFT SEAL
WITH DUST SEAL



ROTATING SHAFT /HOUSING SEAL
WITH DUST LIP (DOUBLE ACTING)



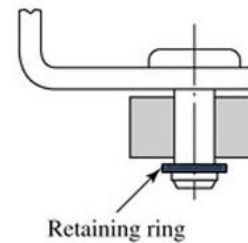
MALE THREADS



FEMALE THREADS SECTION AND HIDDEN



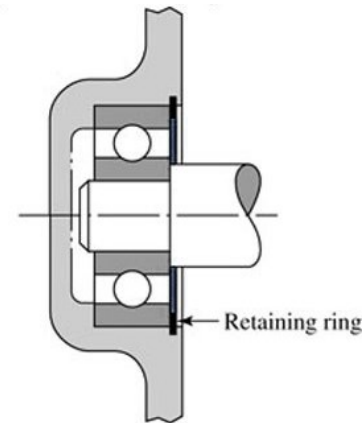
(a)



(b)

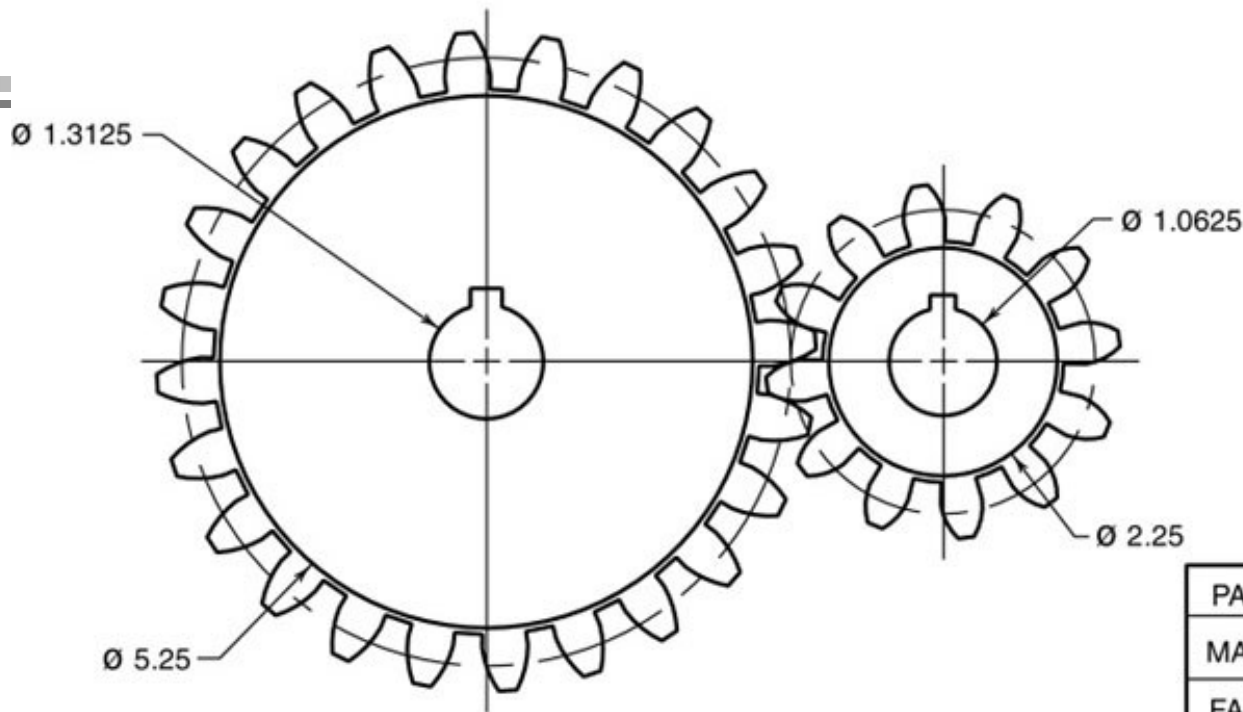


(c)



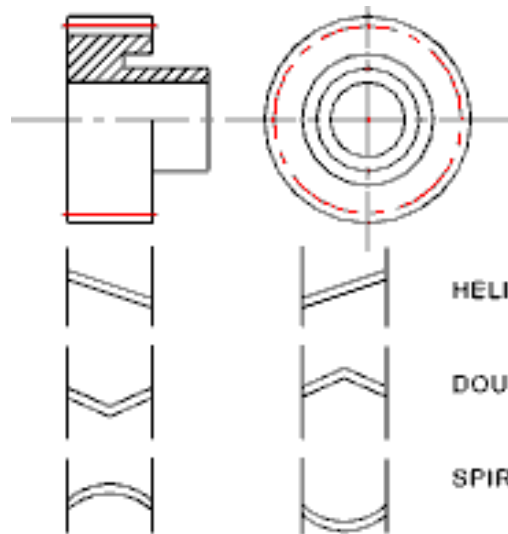
(d)

NOTE: KEYWAY FOR GEAR 5/16 X 5/32
KEYWAY FOR PINION 1/4 X 1/8



CUTTING DATA	GEAR	PINION
NO. OF TEETH	24	12
DIA. PITCH	4	4
TOOTH FORM	14 1/2° INV.	14 1/2° INV.
WHOLE DEPTH	.5393	.5393
CHORDAL ADD.	.3918	.3923
PITCH DIA.	6	3
CIRC. THICK.	.3925	.3925
WORK DEPTH	.25	.25

	GEAR	PINION
PART NUMBER	YSS624	YSS612
MATERIAL	STEEL	STEEL
FACE WIDTH	3.5	3.5



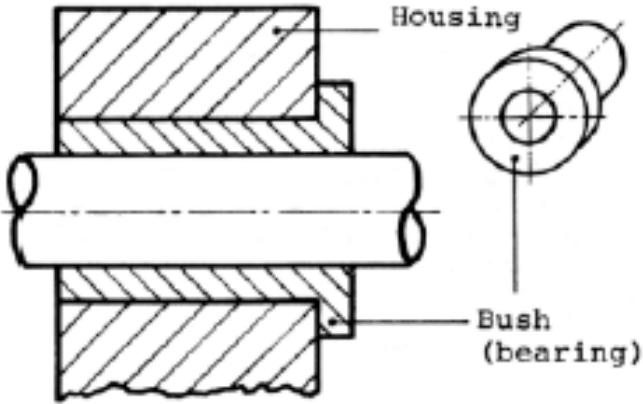
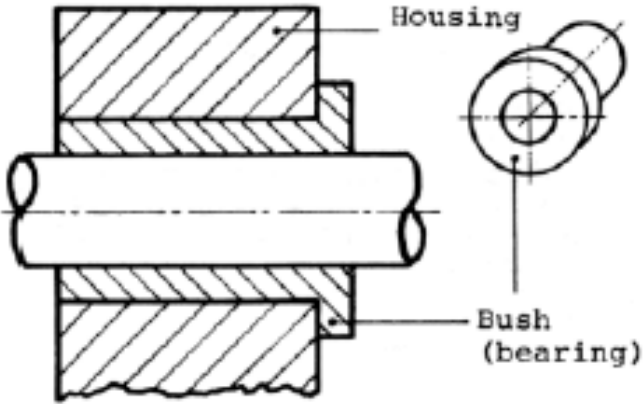
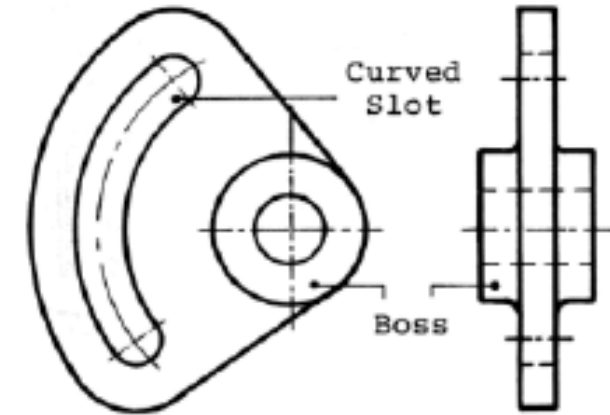
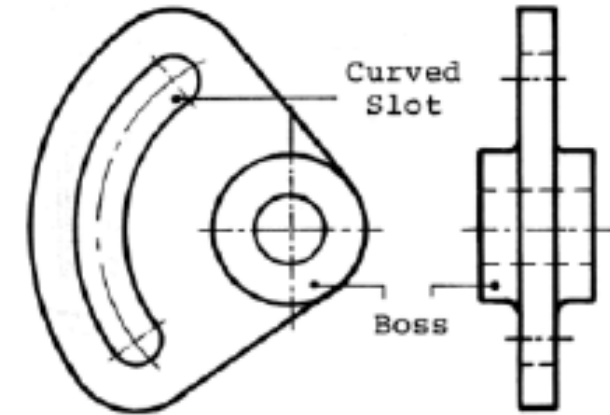
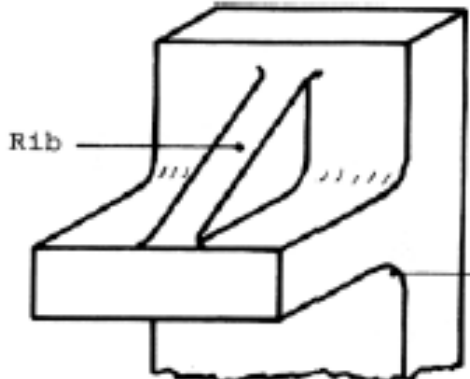
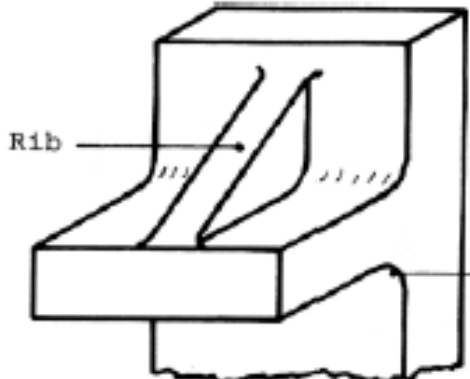
HELICAL RIGHT AND LEFT

DOUBLE HELICAL

SPIRAL

Gears

Terminology and representation of standard components

<p>General:</p> <p>Housing: A component into which a 'male' mating part fits, sits or is 'housed'.</p>	 <p>The diagram shows a cross-section of a housing (hatched) with a bush (bearing) inserted into it. A separate view shows the bush as a cylindrical sleeve with a central hole.</p>
<p>Bush/bearing: A removable sleeve or liner. Known also as a simple or plane bearing.</p>	 <p>The diagram shows a cross-section of a bush (bearing) inserted into a housing. A separate view shows the bush as a cylindrical sleeve with a central hole.</p>
<p>Boss: A cylindrical projection on surface of component.</p>	 <p>The diagram shows a cross-section of a component with a curved slot and a boss. A separate view shows the boss as a cylindrical projection on a flat surface.</p>
<p>Curved slot: Elongated hole, whose centerline lies on an arc. Used usually on components requiring adjustment.</p>	 <p>The diagram shows a cross-section of a component with a curved slot and a boss. A separate view shows the boss as a cylindrical projection on a flat surface.</p>
<p>Rib: A reinforcement, positioned to stiffen surfaces.</p>	 <p>The diagram shows a cross-section of a component with a rib. A separate view shows the rib as a rectangular reinforcement on a flat surface.</p>
<p>Fillet: A radius or rounded portion suppressing a sharp internal corner.</p>	 <p>The diagram shows a cross-section of a component with a fillet. A separate view shows the fillet as a rounded portion on a sharp internal corner.</p>

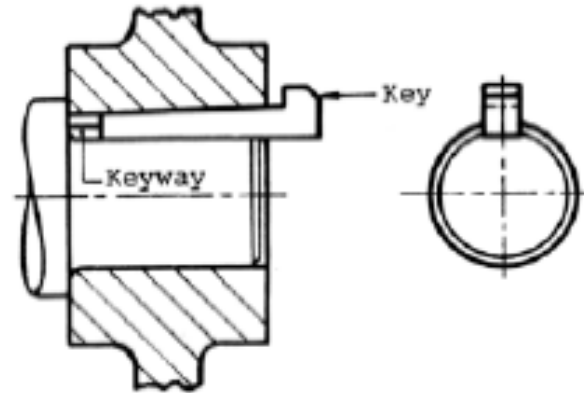
Terminology and representation of standard components

Key:

A small block or wedge inserted between a shaft and a mating part (a hub). Used to prevent relative rotation of the two parts.

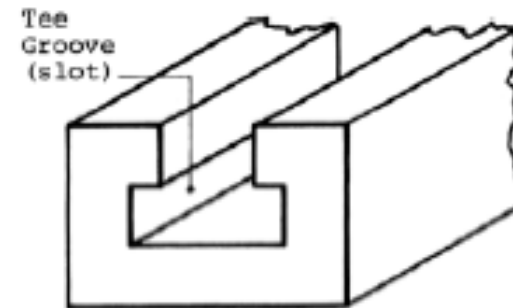
Key way:

A parallel sided slot or groove cut into a bore or a shaft, to 'house' a mating key.



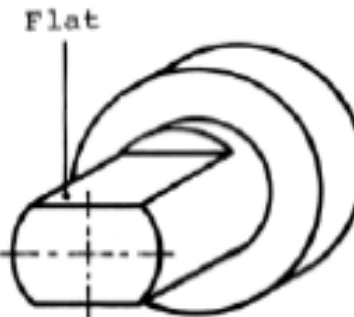
Tee Groove (slot):

Machined to 'house' mating fixing bolts and prevent them from turning.



Flat:

A surface machined parallel to the shaft axis.



Terminology and representation of standard components

Fasteners:

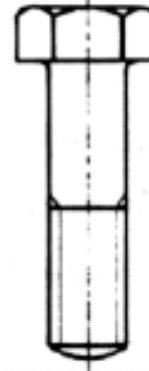
Bolts, screws & studs:

Threaded fasteners. Bolts have a shank partially threaded, whereas screws are threaded along the entire length.

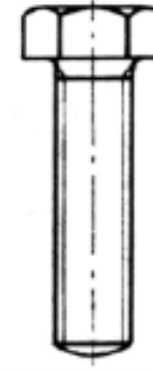
For guidance on dimensioning, see next page.

The last three examples here are called set screws and are used to position or lock components.

HEXAGON
HEAD
BOLT



HEXAGON
HEAD
SCREW



STUD



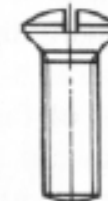
Cheese
head



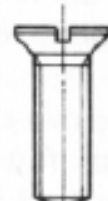
Round
head



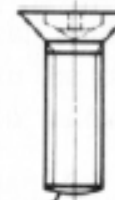
Fillister
head



Instrument
screw



Countersunk
head



ROUND



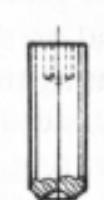
FLAT



CONE



DOG

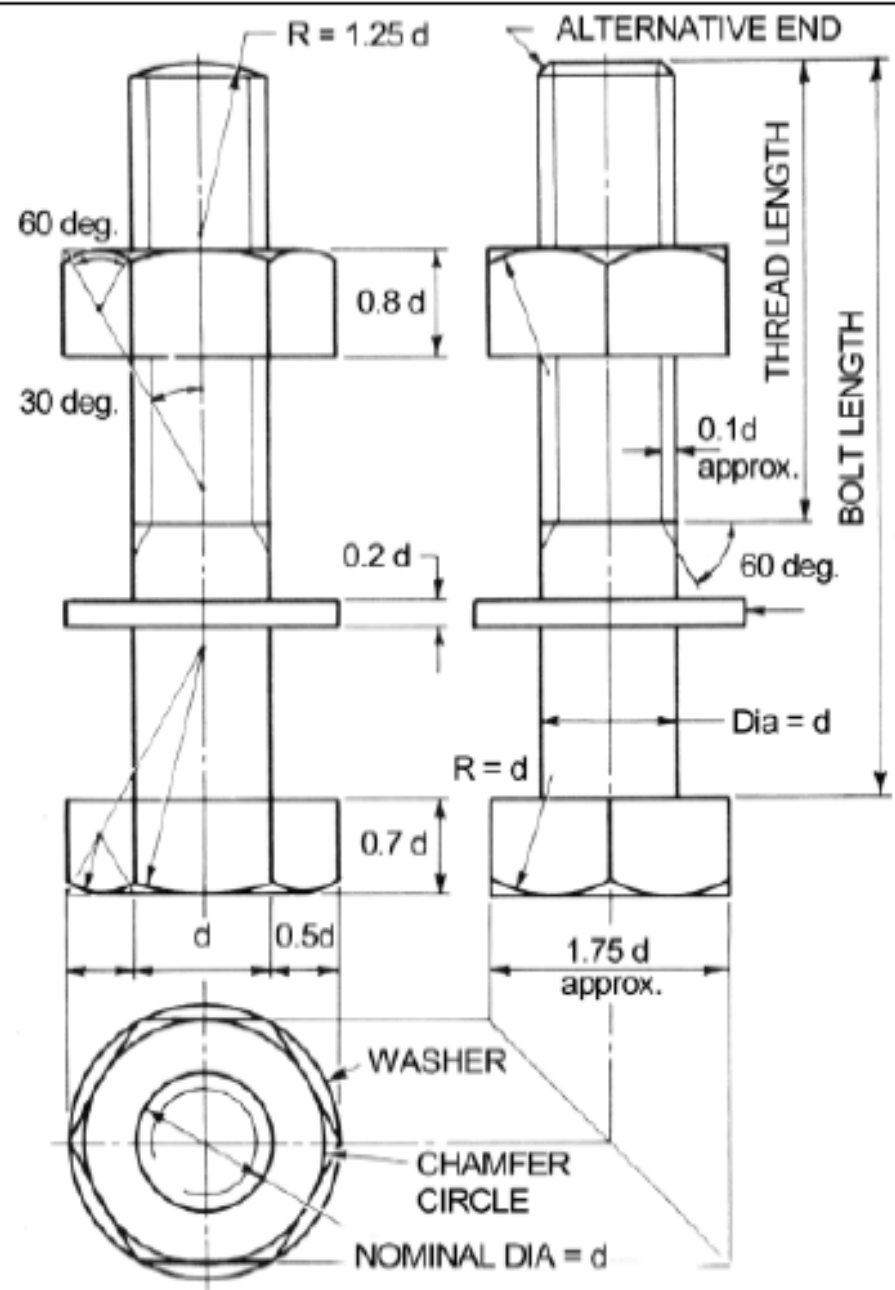


CUP

Terminology and representation of standard components

This diagram gives approximate dimensioning methods for drawing hexagon headed metric bolts, nuts and plane washers.

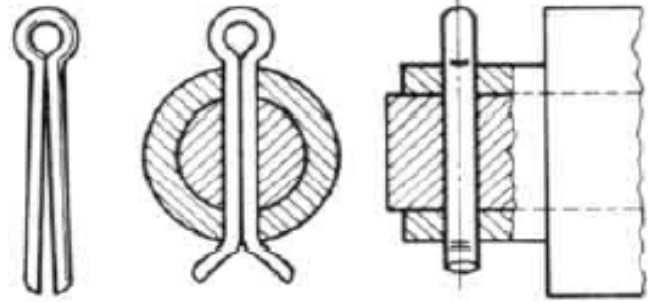
(Manufacturers data sheets may give more accurate measurements.)



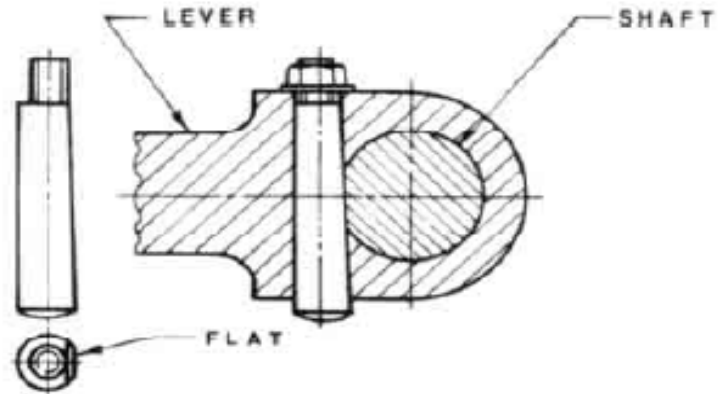
Terminology and representation of standard components

Pins:

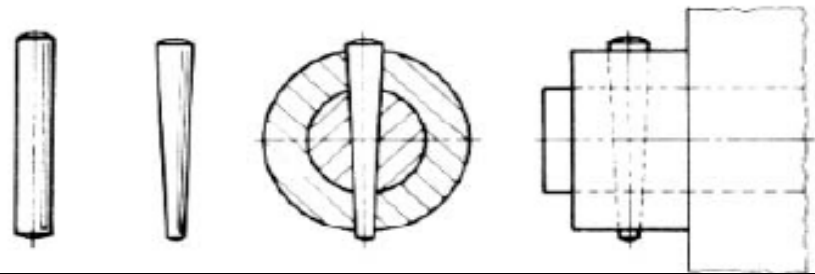
Split Cotter Pin:
Used to lock components,
prevent fasteners from
coming 'un-fastened'.
e.g. lock-nuts on suspension
systems.



Cotter Pin:
Used to retain components,
usually where loads are
transmitted.

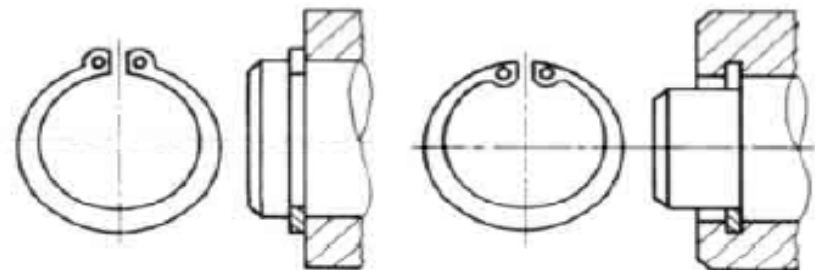


Dowel Pin & Taper Pin:
Provides location, alignment.



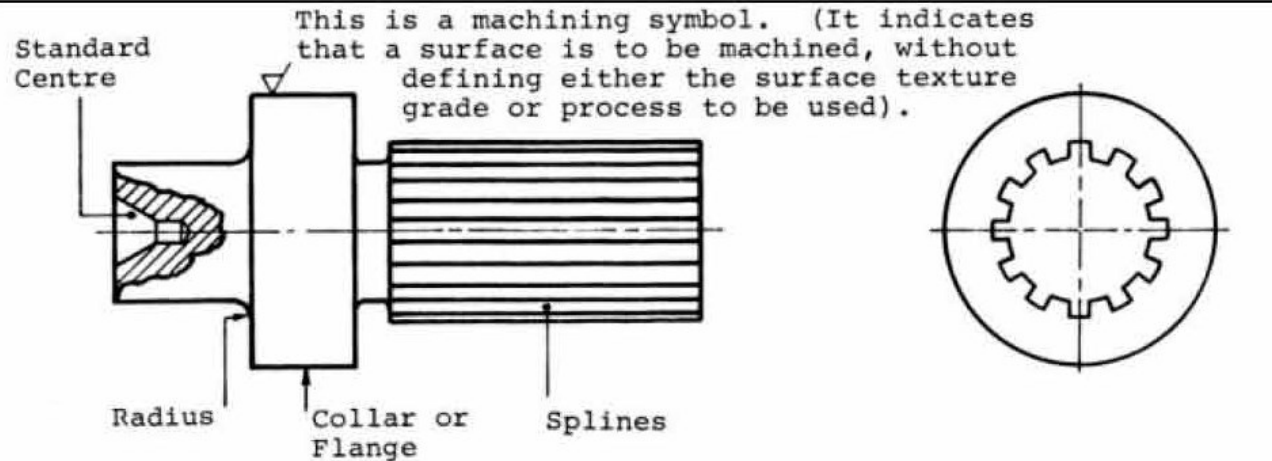
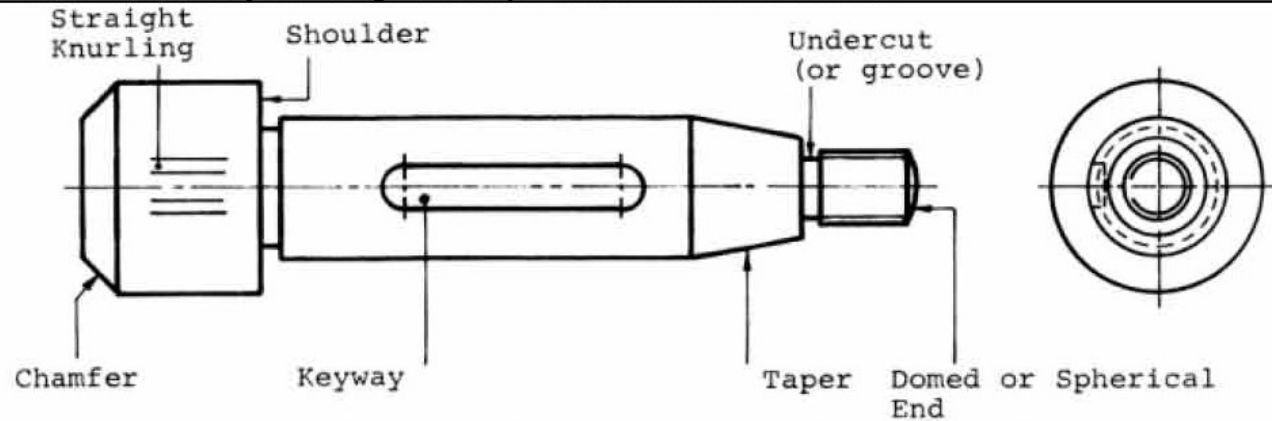
Circlip:

Internal & external.



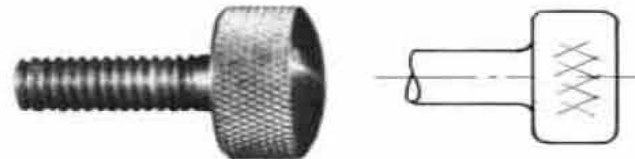
Terminology and representation of standard components

Features usually relating to components turned on a lathe:

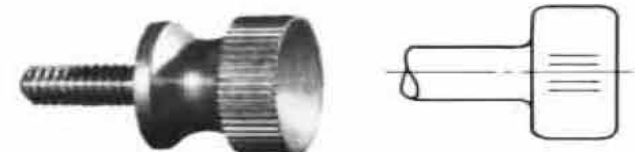


Knurling:

Diamond.

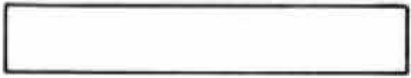

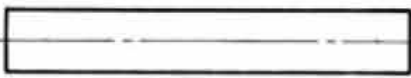
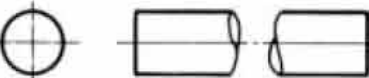
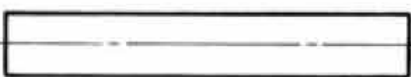



Straight.



Terminology and representation of standard components

Long components:

	<i>Subject</i>	<i>Convention</i>
Rectangular bar:		
Round bar:		
Round tube:		

Holes:

Drilled:

Loose tolerance, for pilot holes or clearance holes for fasteners.

Reamed:

Accurate finishing process after drilling or boring.

Counterbore:

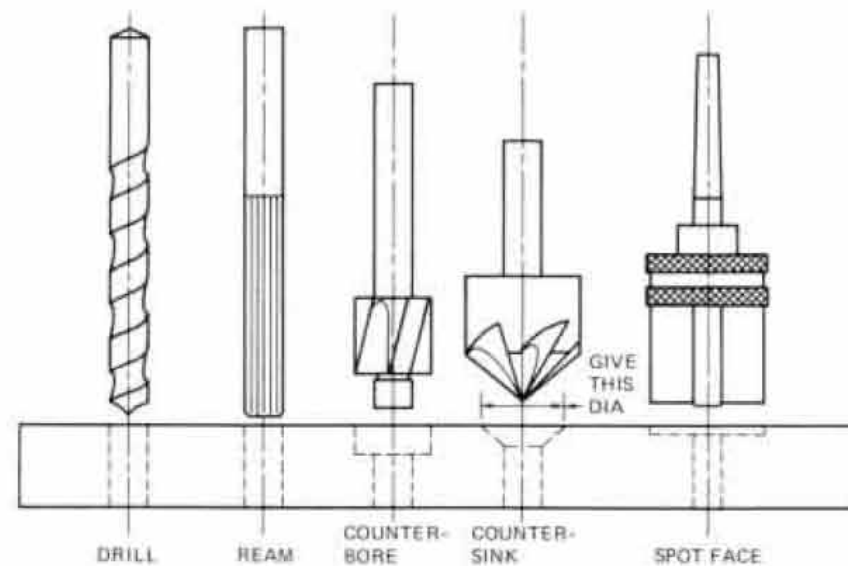
Usually used to recess the head of a square shouldered fastener.

Countersunk:

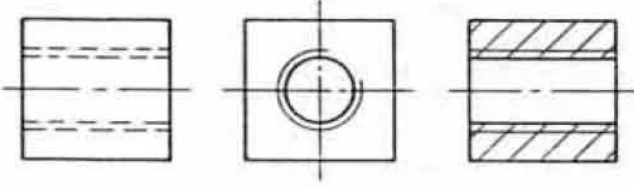
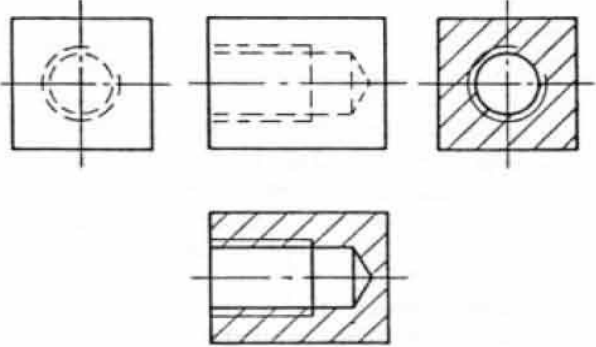
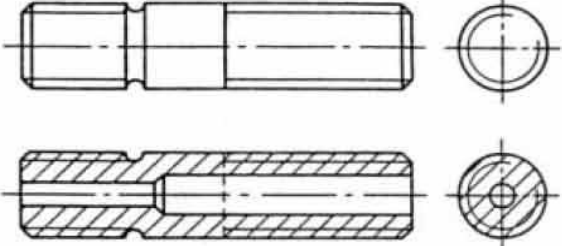
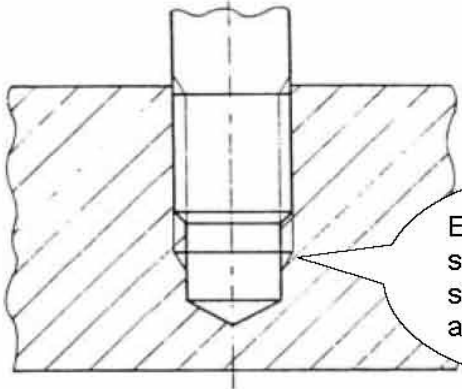
Usually used to recess the head of a countersink screw.

Spotface:

Used to clean up and level the surrounding area, usually for a fastener or something such as a hydraulic fitting using a seal.

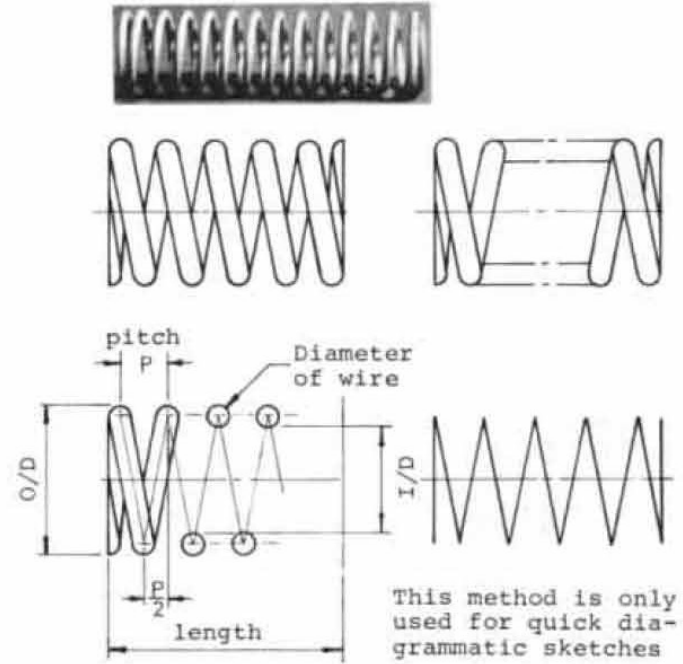


Terminology and representation of standard components

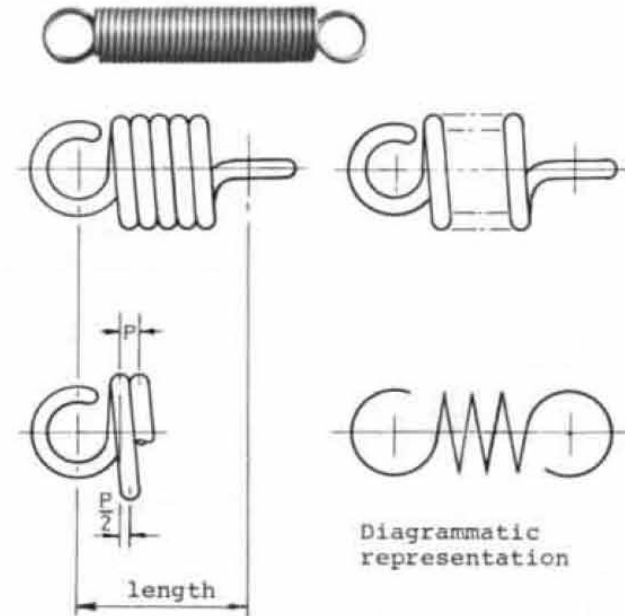
<p>Screw threads: Female thread, through: Usually drilled and tapped.</p>	
<p>Female thread, blind: Usually drilled and tapped.</p>	
<p>Male thread: Usually cut with a die, turned or rolled.</p> <p>Note use of undercut or groove and appearance of thread in sectioned view.</p>	
<p>Male & Female: e.g. a fastener in a tapped hole.</p> <p>Note here that the tapped hole is sectioned, the fastener is not.</p>	 <p>End of thread is sometimes not shown with this angled line.</p>

Terminology and representation of standard components

Springs:
Compression:



Tension:



Terminology and representation of standard components

Bearings:

Some examples of rolling element bearings. Arrows indicate directions of load bearing.

Deep groove (near).

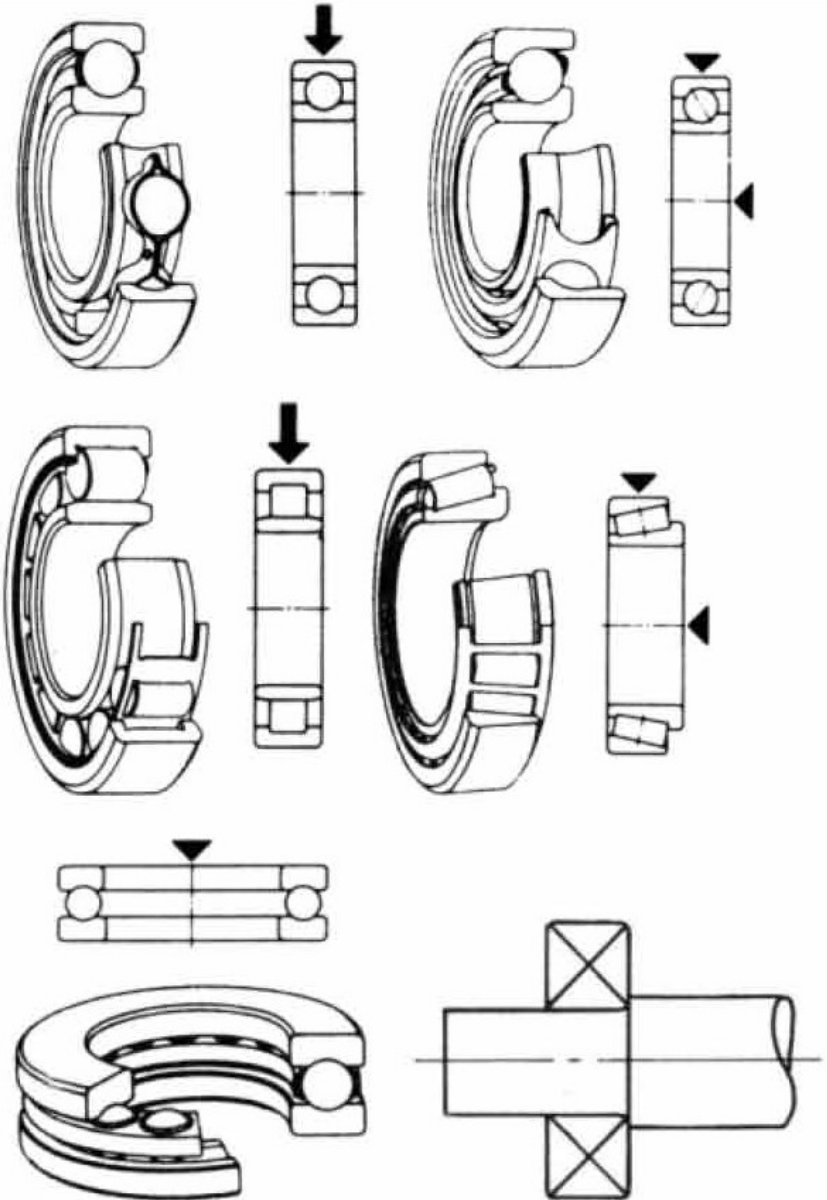
Angular contact (far).

Roller (near).

Taper roller (far).

Thrust (near).

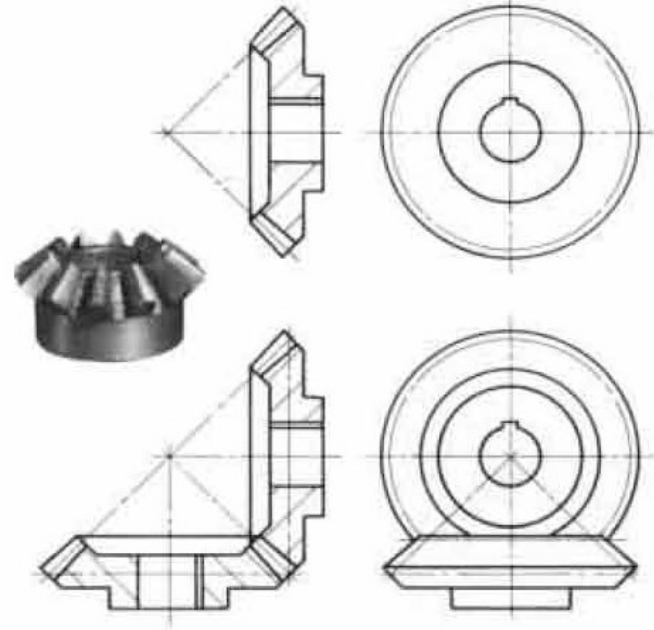
Standard drawing representation of a bearing.



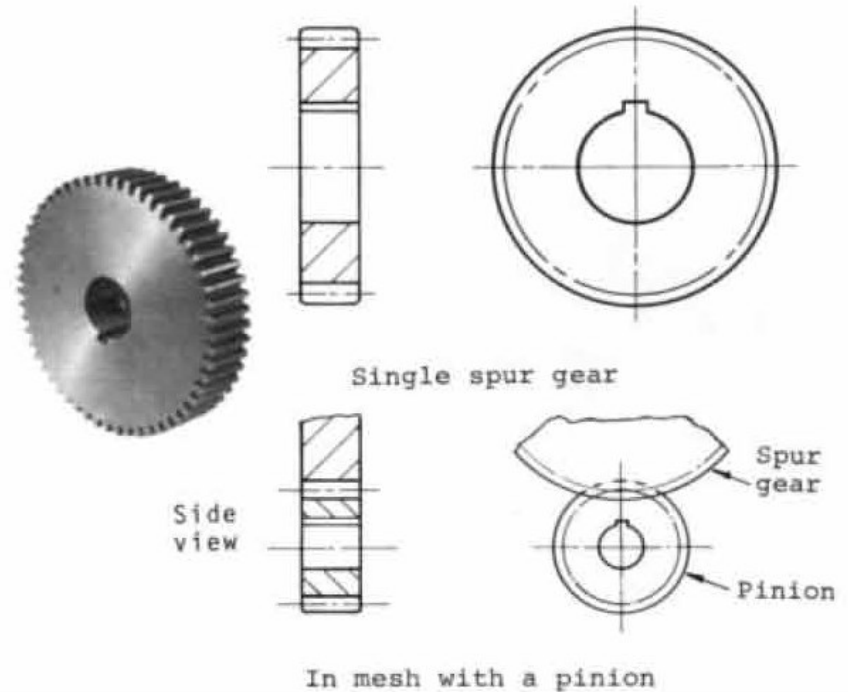
Terminology and representation of standard components

Gears:

Bevel:

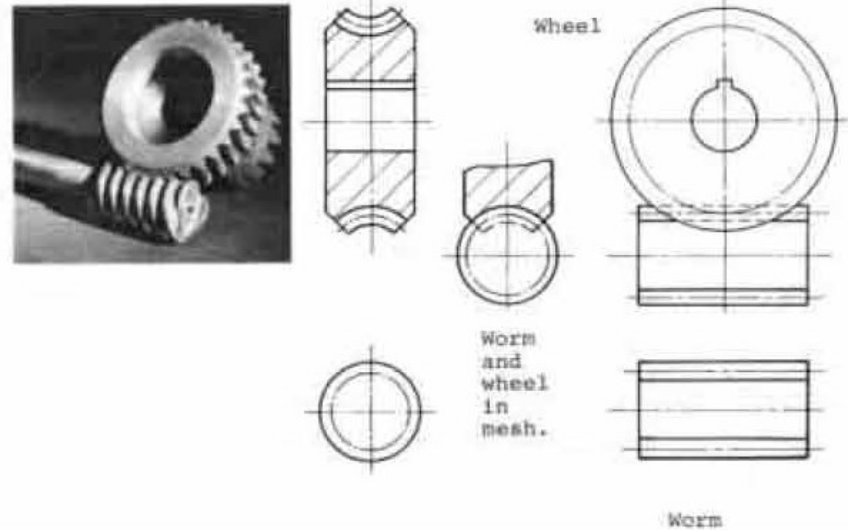


Spur:



Terminology and representation of standard components

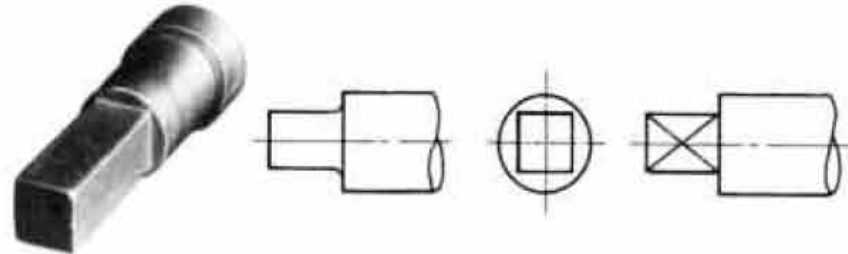
Worm & wheel:



Shaft ends:

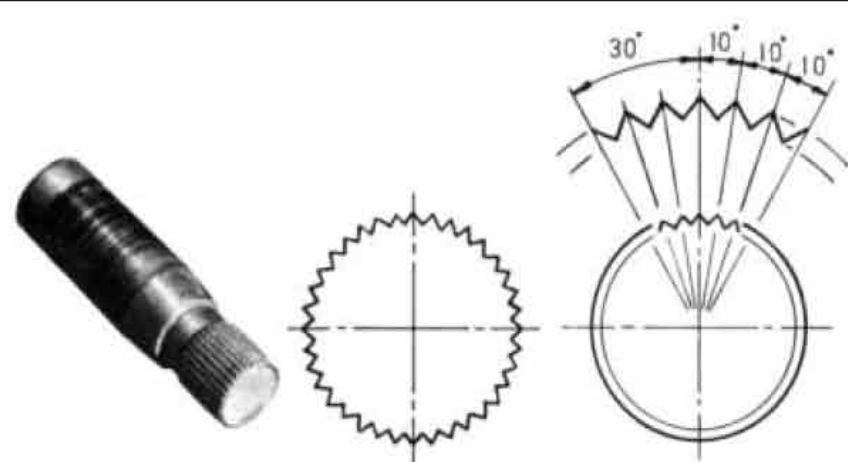
Square:

Frequently used for hand driven adjustments with removable handles, such as those found on machine tools, etc.



Serrations:

Often used for push fit components such as plastic fans or pulleys, or levers such as motorcycle gear shifters.



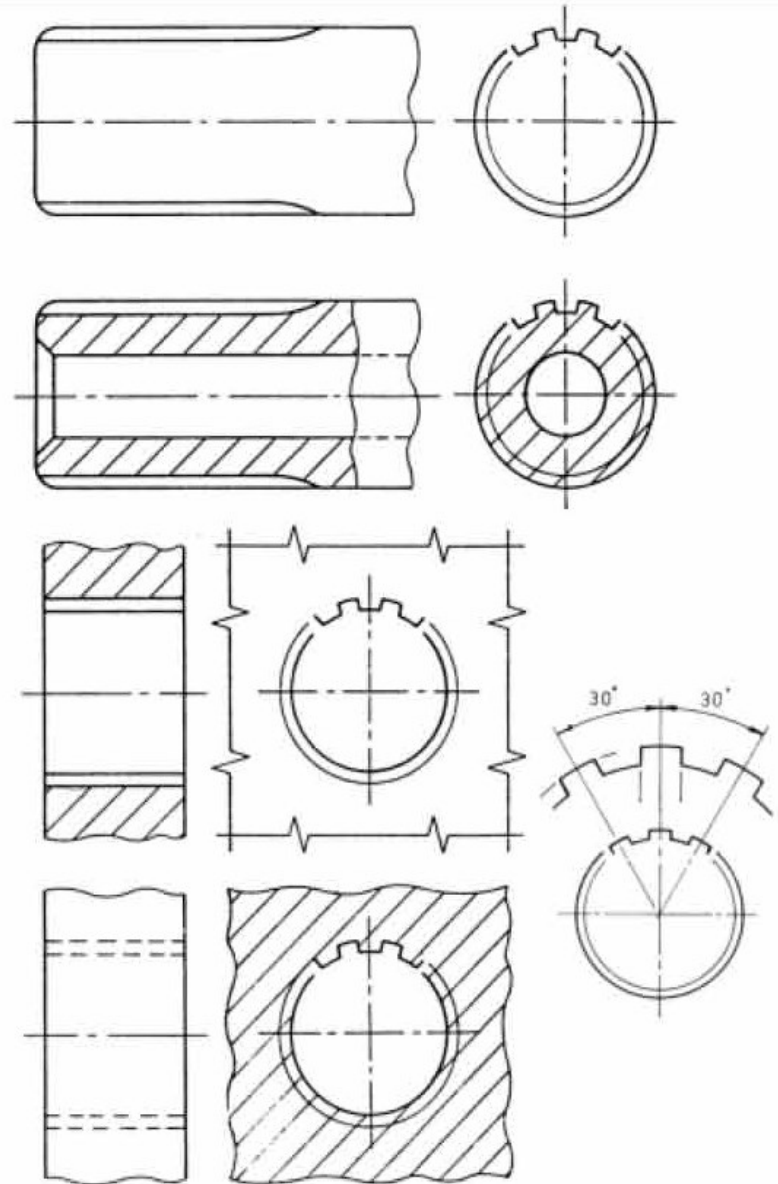
Terminology and representation of standard components

Splines:

Usually used for transmitting rotational torque and allowing an axial 'sliding' movement.

Examples can be found on automotive drive shafts.

The figures opposite show splined shafts and housings in sectioned and non-sectioned views.



BS 8888 for features and components

- **Representation of features**
 - **BS EN ISO 6411 Technical drawings – Simplified representation of centre holes**
 - **BS EN ISO 6413 Technical drawings – Representation of splines and serrations**
 - **BS EN ISO 15785 Technical drawings – Symbolic presentation and indication of adhesive, fold and pressed joints**
 - **BS EN 22553 Welded, brazed and soldered joints – Symbolic representation on drawings**
 - **NOTE The BS ISO 128 series of standards covers the general subject of feature representation.**
- **Representation of components**
 - **BS EN ISO 2162-1 Technical product documentation – Springs – Part 1: Simplified representation**
 - **BS EN ISO 2162-2 Technical product documentation – Springs – Part 2: Data for cylindrical helical compression springs**
 - **BS EN ISO 2162-3 Technical product documentation – Springs –**
- **BS EN ISO 2203 Technical drawings – Conventional representation of gears**
- **BS EN ISO 5845-1 Technical drawings – Simplified representation of the assembly of parts with fasteners – Part 1: General principles**
 - **BS EN ISO 6410-1 Technical drawings – Screw threads and threaded parts – Part 1: General conventions**
 - **BS EN ISO 6410-2 Technical drawings – Screw threads and threaded parts – Part 2: Screw thread inserts**
 - **BS EN ISO 6410-3 Technical drawings – Screw threads and threaded parts – Part 3: Simplified representation**
- **BS EN ISO 8826-1 Technical drawings – Roller bearings – Part 1: General simplified representation**
- **BS EN ISO 8826-2 Technical drawings – Roller bearings – Part 2: Detailed simplified representation**
- **BS EN ISO 9222-1 Technical drawings – Seals for dynamic application – Part 1: General simplified representation**
- **BS EN ISO 9222-2 Technical drawings – Seals for dynamic application – Part 2: Detailed simplified representation**

Tolerances

- Definition:
 - » A tolerance is the total permissible variation of a size, or the difference between the maximum and minimum limits of size.
- Why is tolerancing necessary?
 - » It is impossible to manufacture a part to an exact size or geometry
 - » Since variation from the drawing is inevitable the acceptable degree of variation must be specified
 - » Large variation may affect the functionality of the part
 - » Small variation will effect the cost of the part
 - requires precise manufacturing
 - requires inspection and the rejection of parts

Tolerance Declaration

Tolerance can be expressed in different ways:

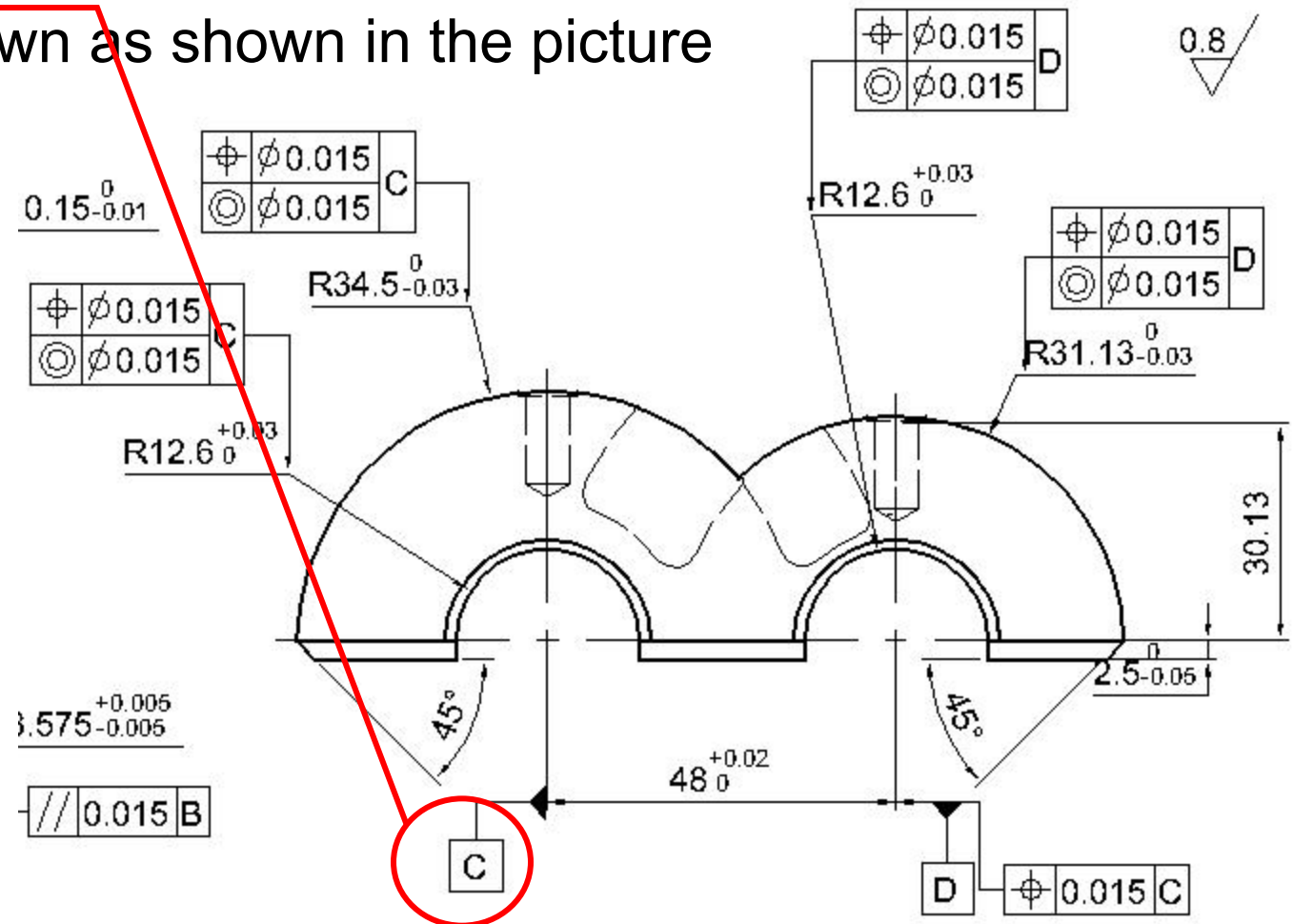
1. Direct tolerancing method (size)
 - » Limits specifying the allowed variation in each dimension (length, width, height, diameter, etc.) are given on the drawing

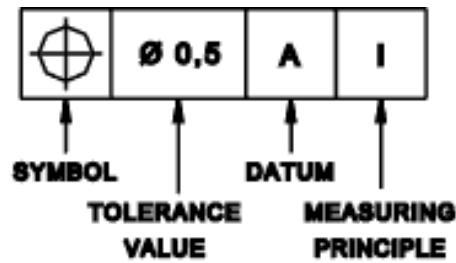
2. General tolerance note
 - » Notes like “ALL DIMENSIONS HELD TO ± 0.05 ”

3. Geometrical tolerancing
 - » Allows for specification of tolerance for the geometry of a part separate from its size
 - » GDT (Geometric Dimensioning and Tolerancing) uses special symbols to control different geometric features of a part

Datums

- Plane surface or axis
- Designated in order that some other feature(s) may relate to it
- **Datums** are drawn as shown in the picture





Geometrical Tolerances

	STRAIGHTNESS
	FLATNESS
	CIRCULARITY
	CYLINDRICITY
	PROFILE OF LINE
	ORIENTATION OF PROFILE
	PROFILE OF SURFACE
	ORIENTATION OF ANY PROFILE SURFACE

	POSITION
	ORIENTATION OF POSITION
	COAXIALITY
	SYMMETRY
	PARALLELISM
	PERPENDICULARITY
	ANGULARITY
	RUN-OUT
	TOTAL RUN-OUT

– **Geometric tolerance** of a feature (point, line, axis, surface) specifies the tolerance zone in which the feature is required to contain.

Notation

50

M

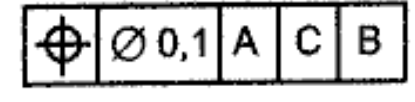
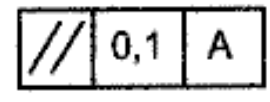
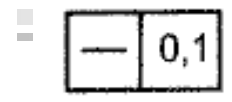
P

THEORETICALLY EXACT DIMENSION

MAXIMUM MATERIAL PRINCIPLE

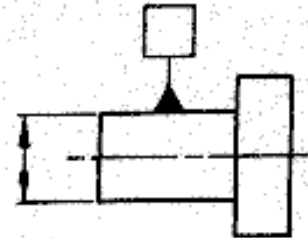
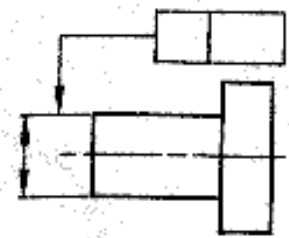
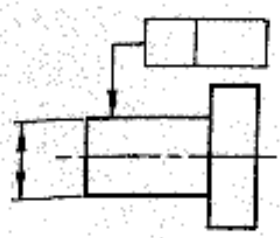
PROJECTED TOLERANCE ZONE

Supplementary symbols



REFERENCE TO FACE SURFACE EDGE OR LINE

Tolerance frame variations

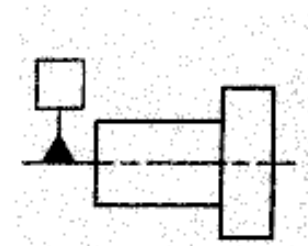
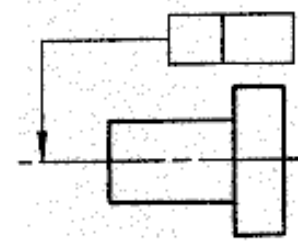
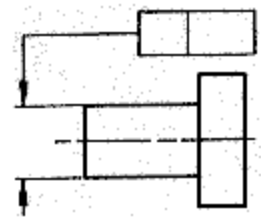
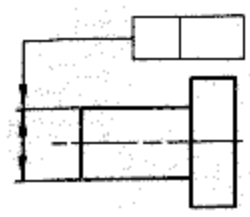


LOCATION OF ARROWHEAD

LOCATION OF DATUM TRIANGLE

REFERENCE TO AXES OR PLANE OF DIMENSIONED FEATURE ONLY

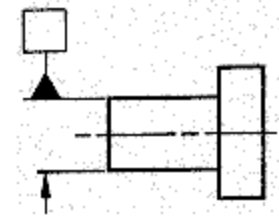
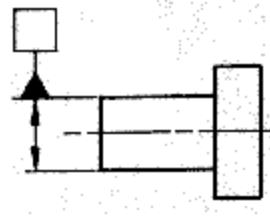
REFERENCE COMMON AXIS OR MEDIAN PLANE OF ALL FEATURES



LOCATION OF ARROWHEAD

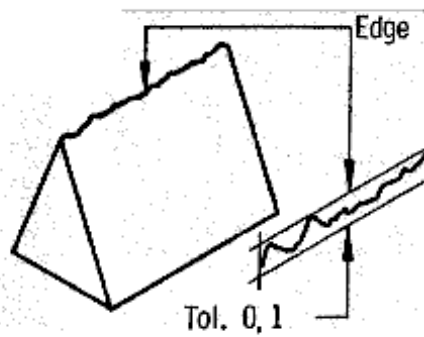
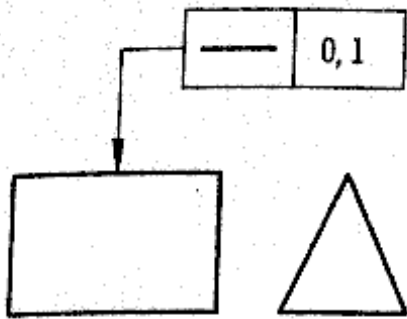
LOCATION OF ARROWHEAD

LOCATION OF DATUM TRIANGLE

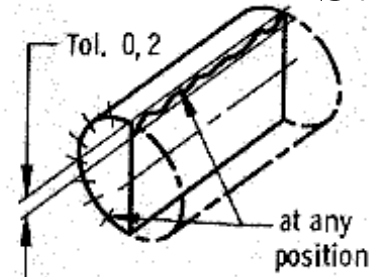
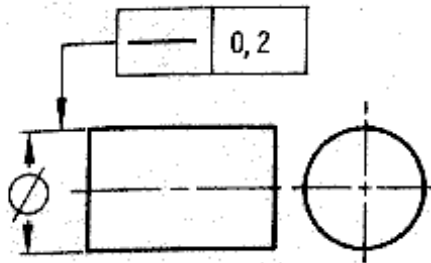


LOCATION OF DATUM TRIANGLE

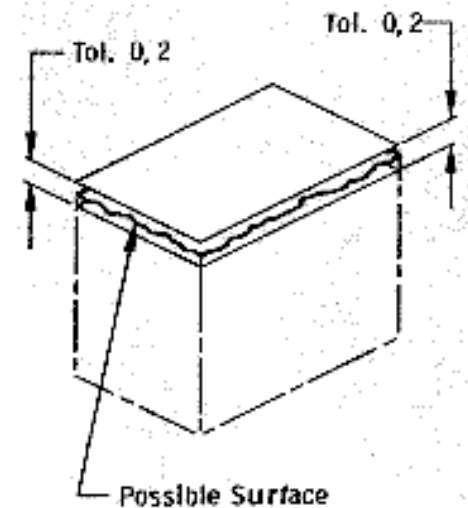
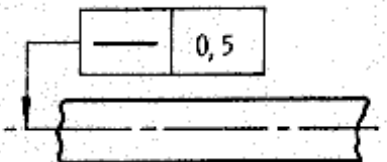
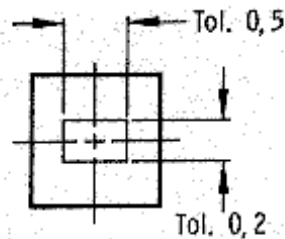
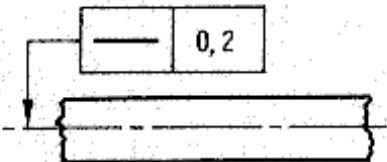
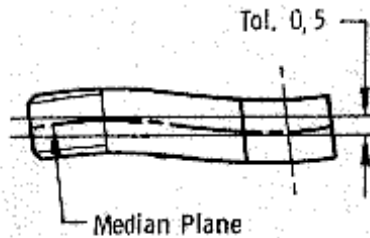
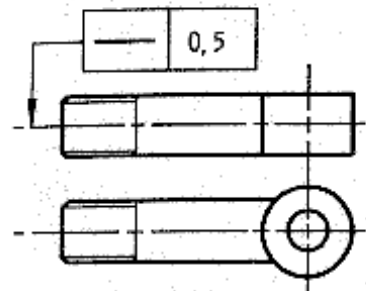
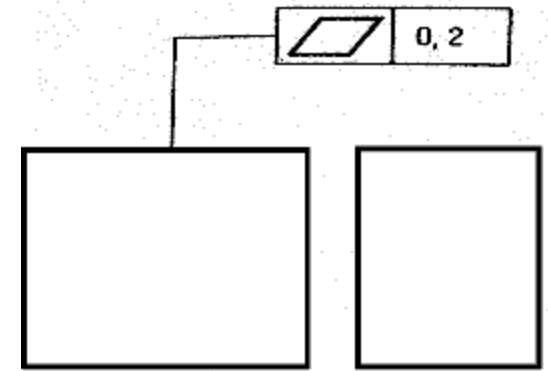
Tolerance examples



Straightness

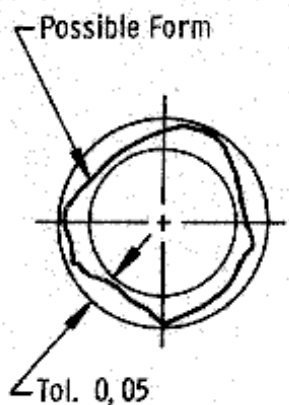
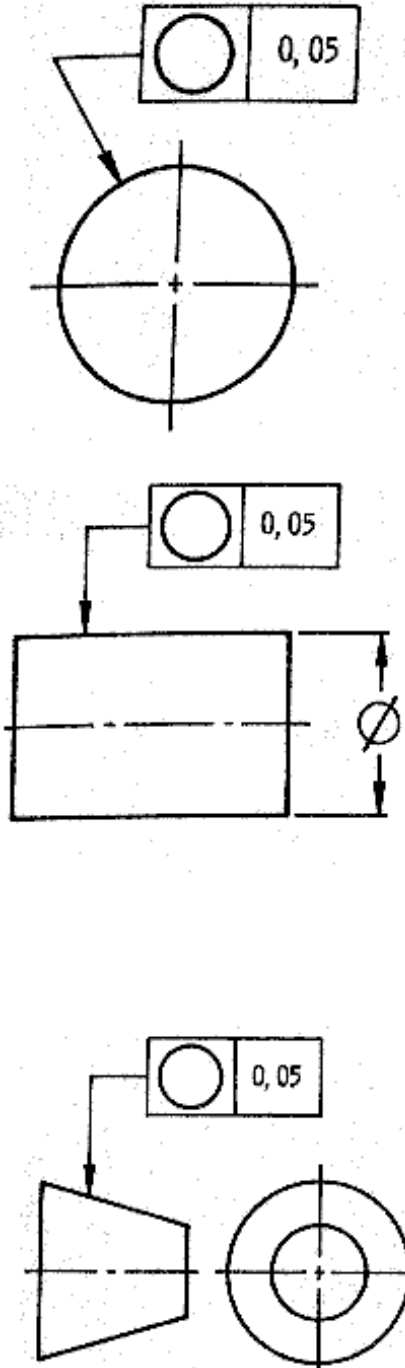


Flatness

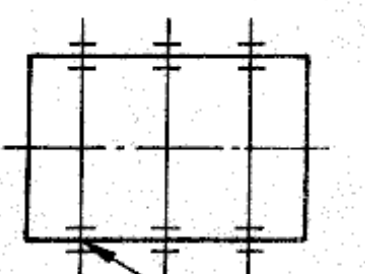


Tolerance examples

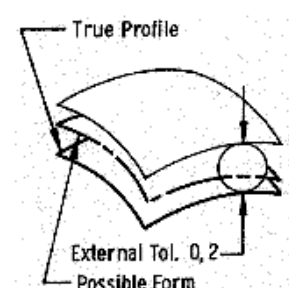
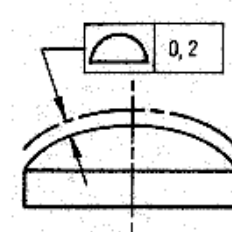
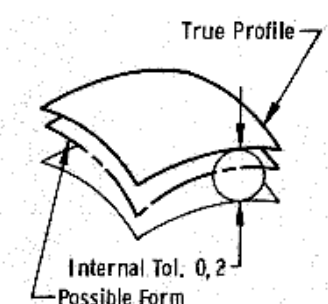
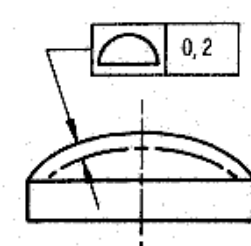
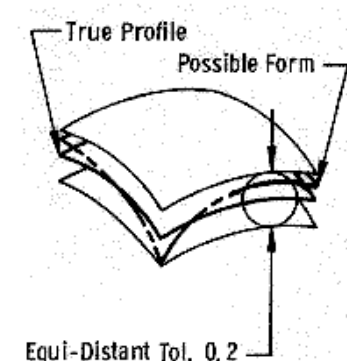
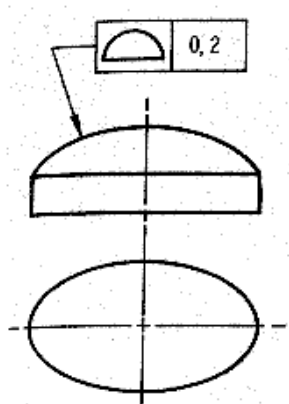
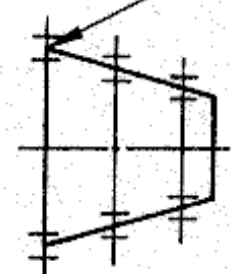
Form



Roundness

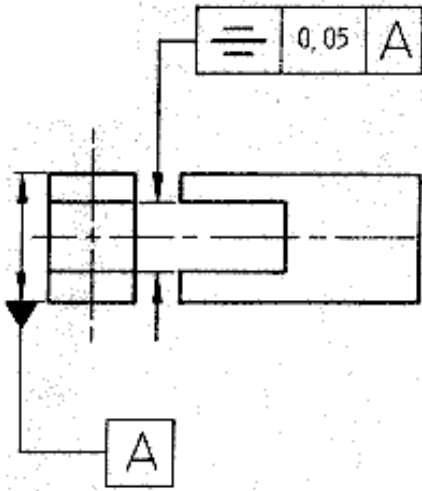


Surface at any cross section square to axis

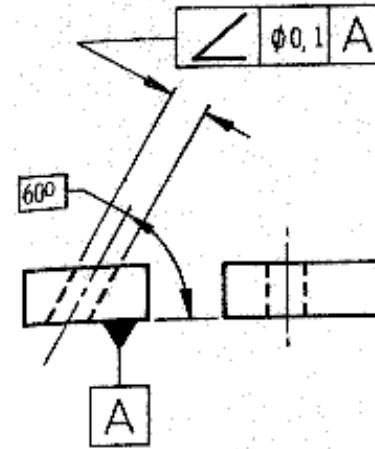
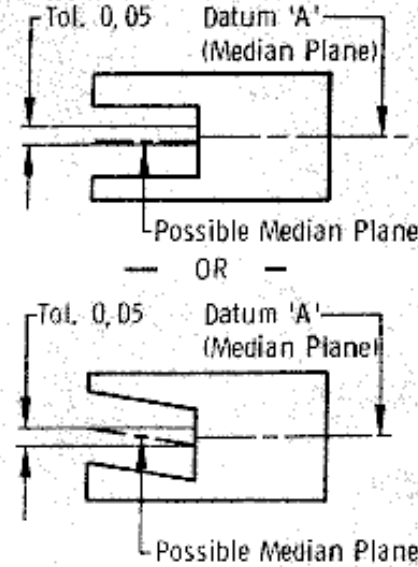


Tolerance examples

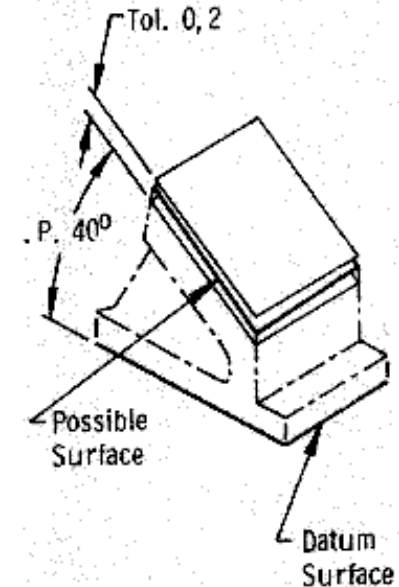
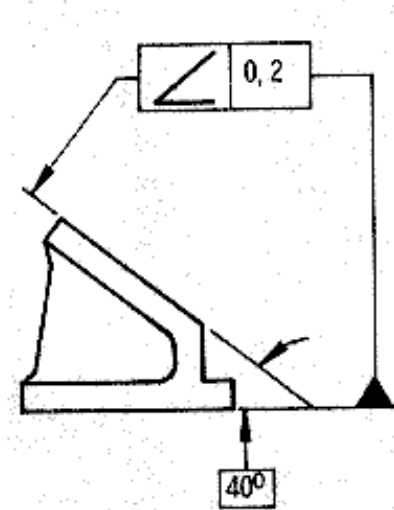
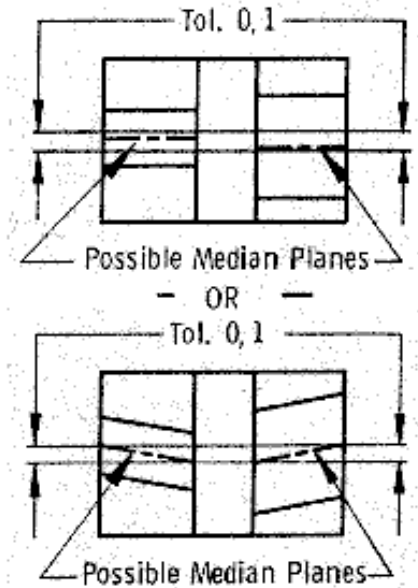
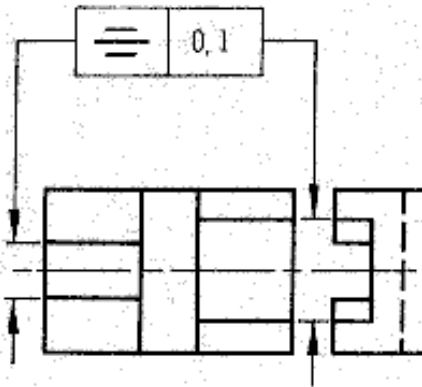
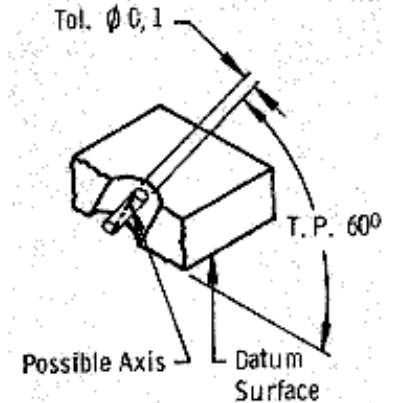
TWO PARALLEL PLANES
EQUI-SPACED ABOUT DATUM



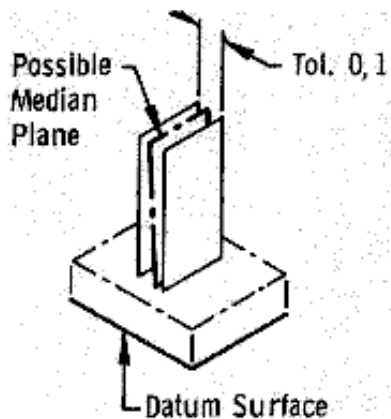
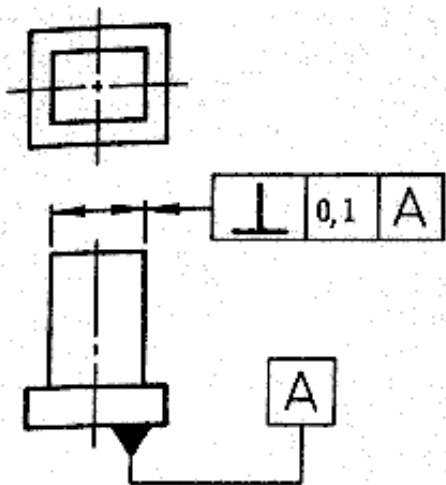
Symmetry



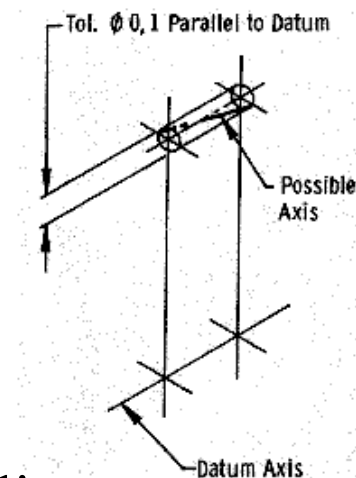
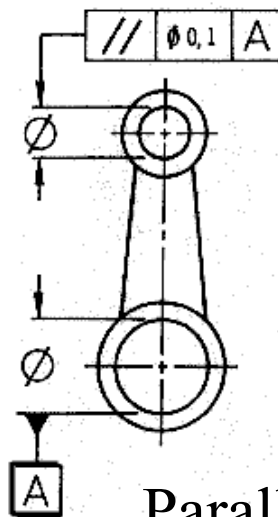
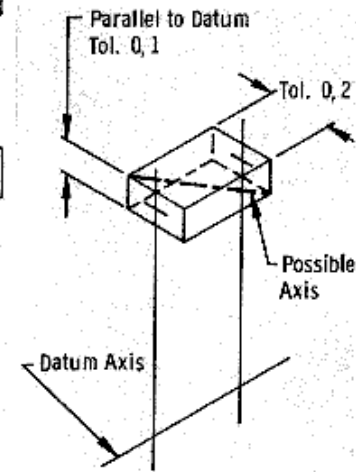
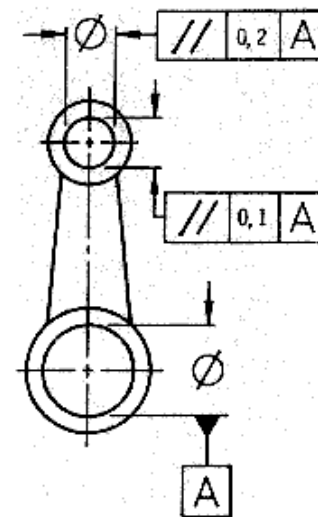
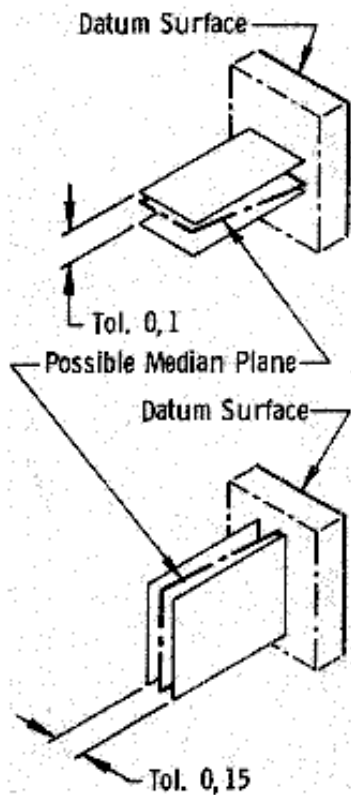
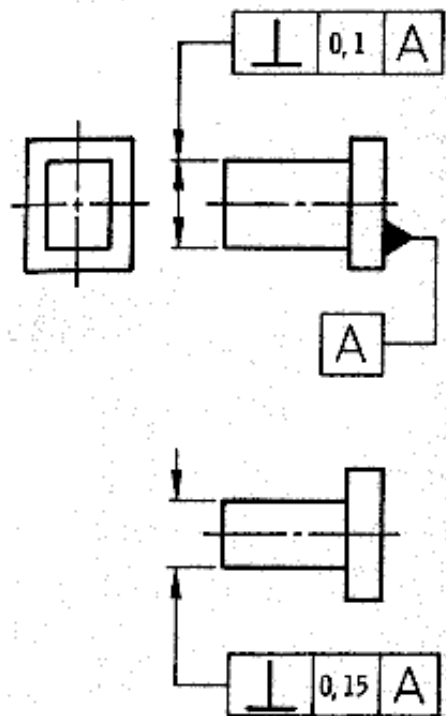
Angularity



Tolerance examples



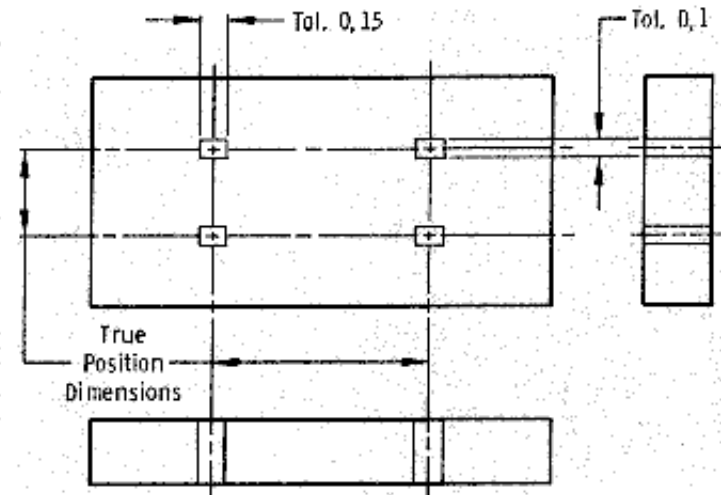
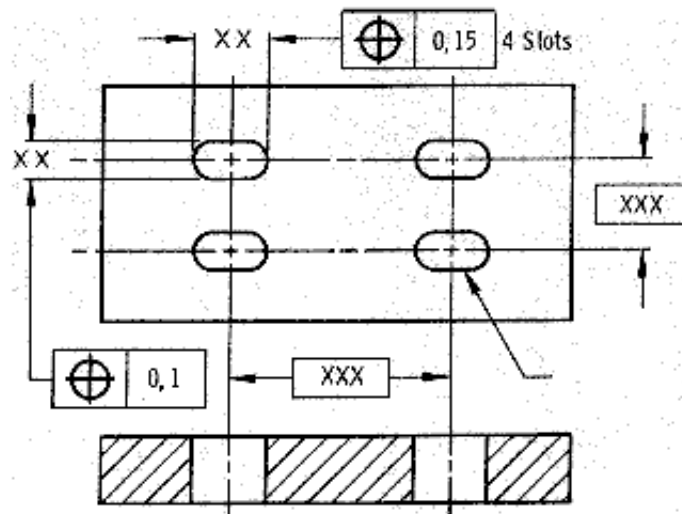
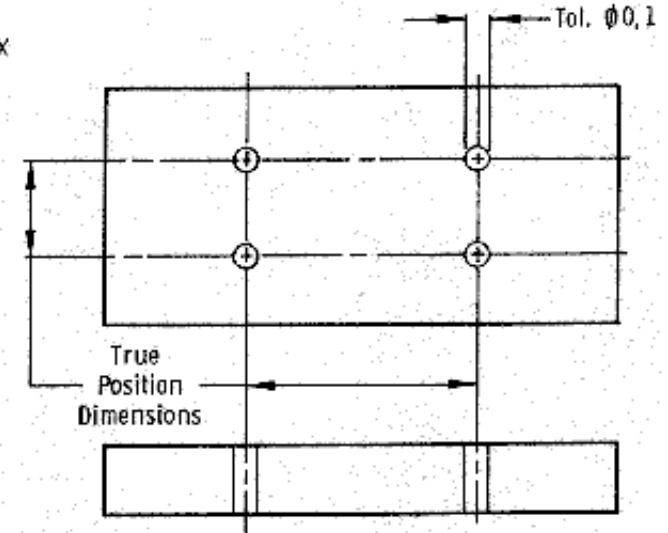
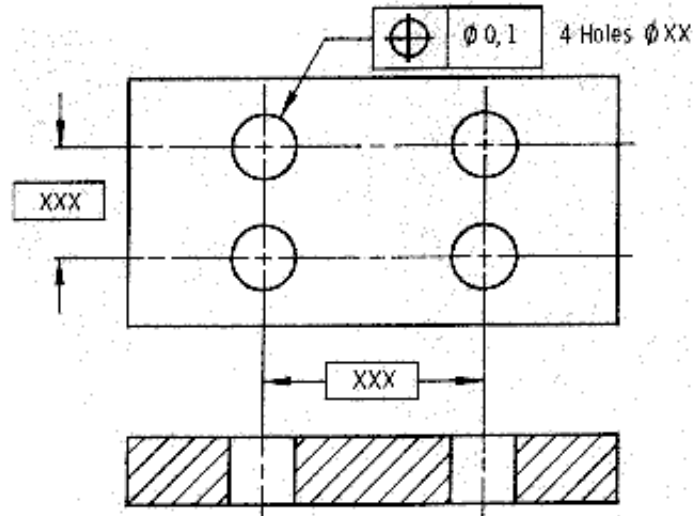
Squareness



Parallelism

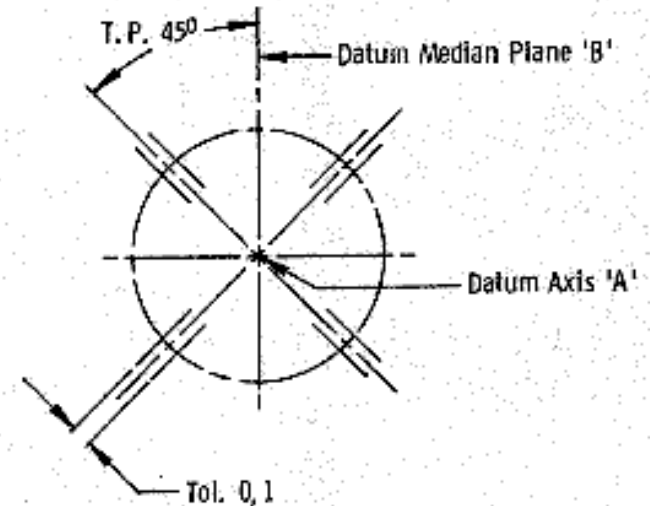
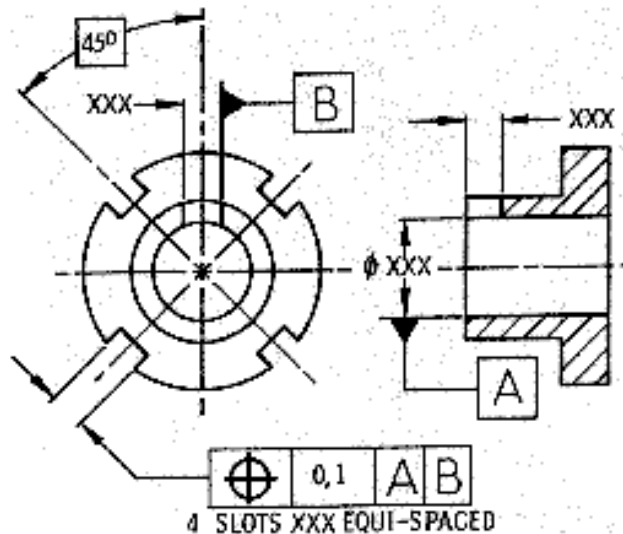
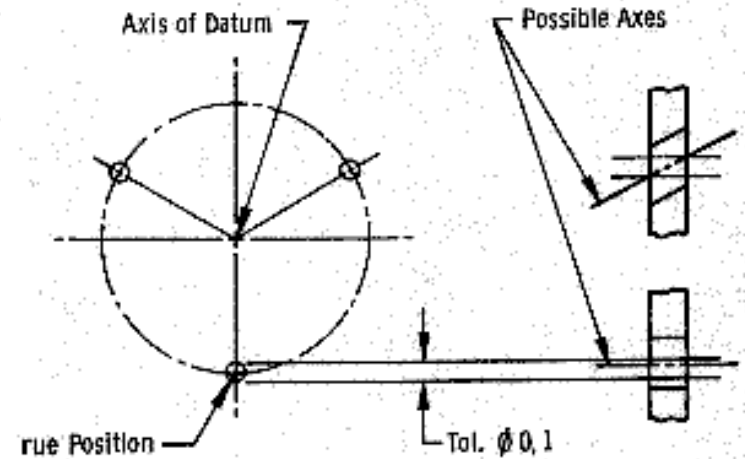
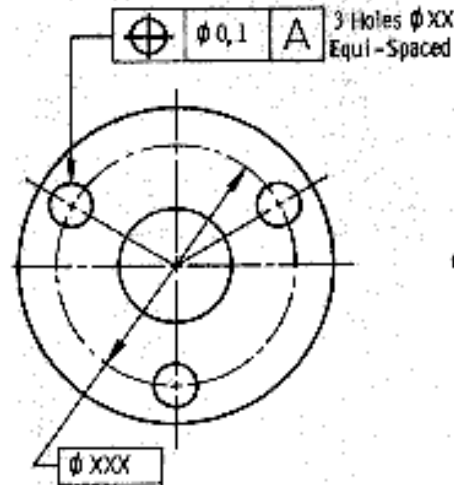
Tolerance examples

Position

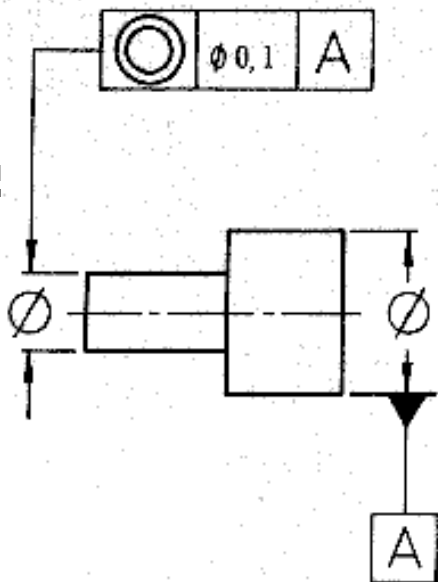


Tolerance examples

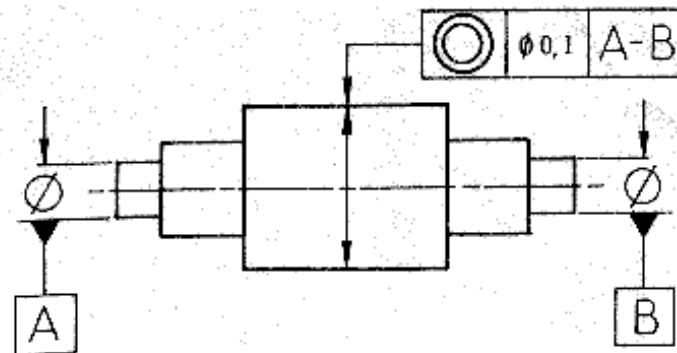
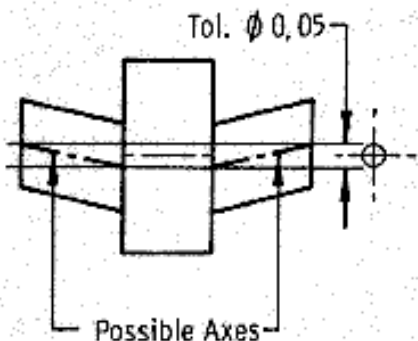
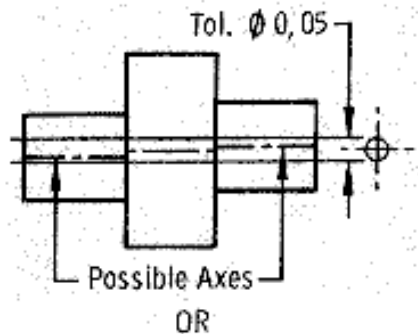
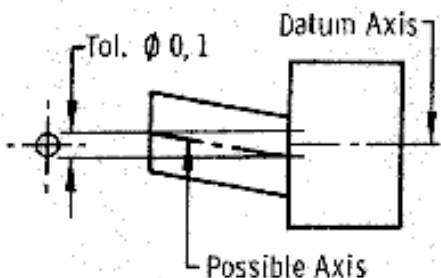
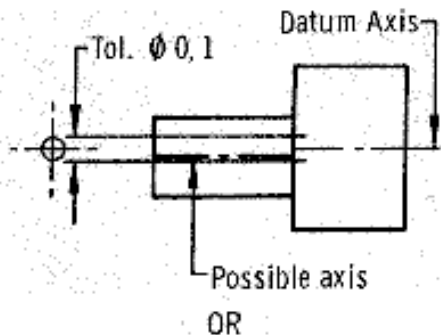
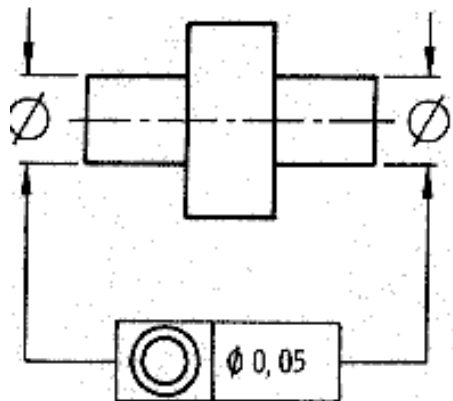
Position



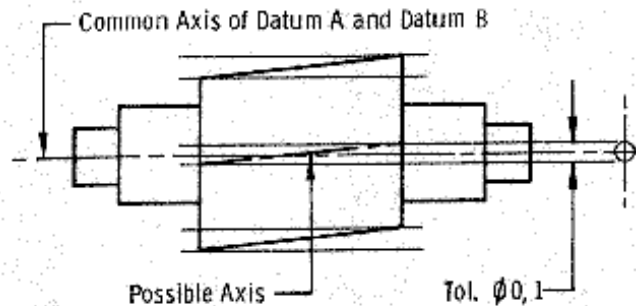
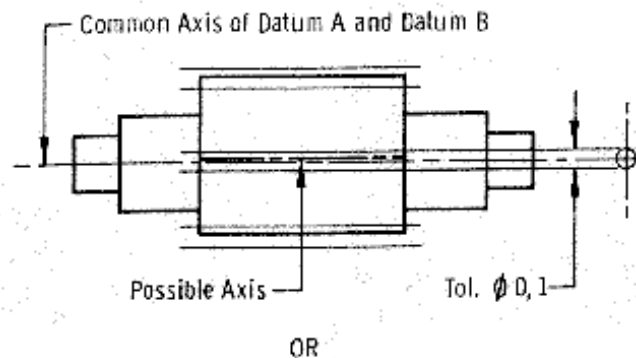
Tolerance examples



Concentricity

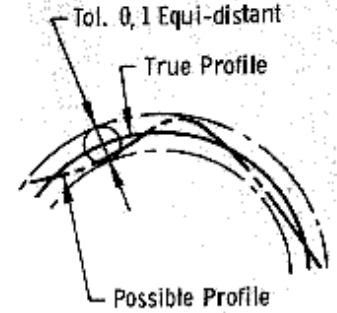
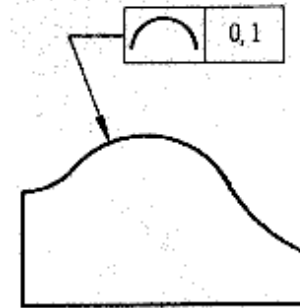
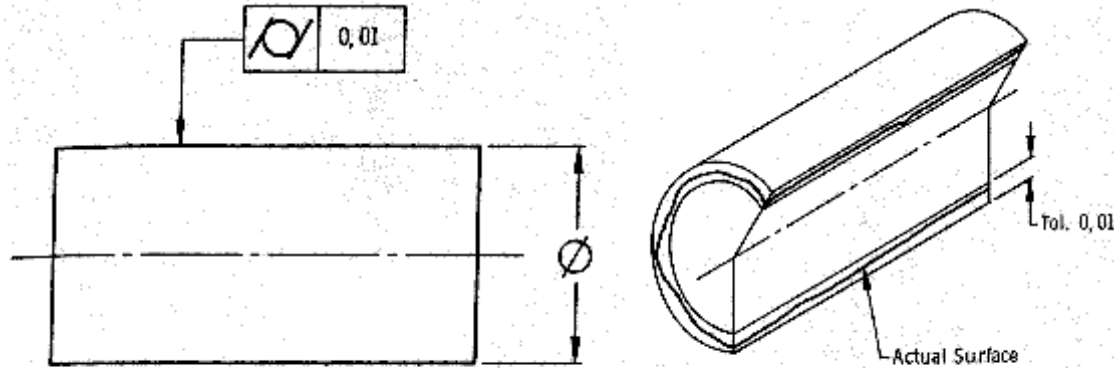


INTERPRETATION
CYLINDER ON DATUM AXIS

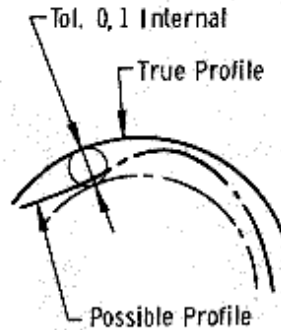
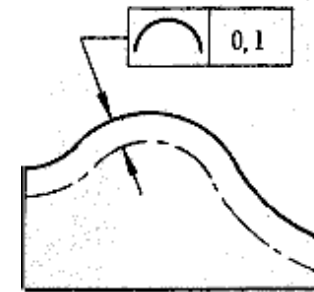
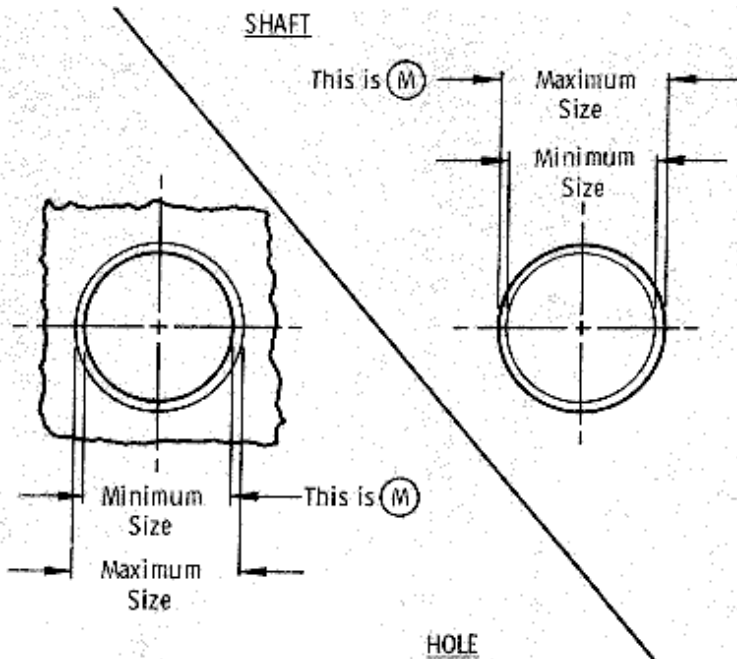


Tolerance examples

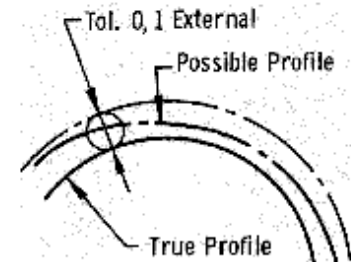
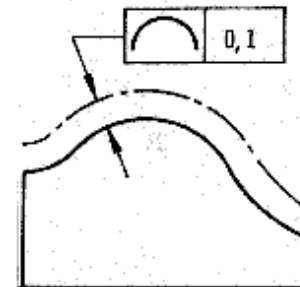
Cilindricity



Maximum material condition

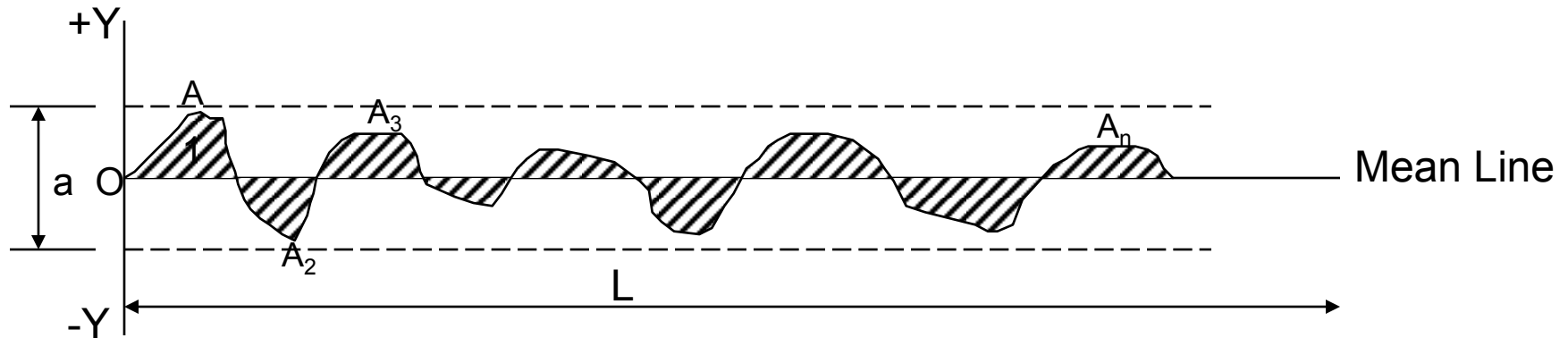


Profile tolerance



Surface Roughness

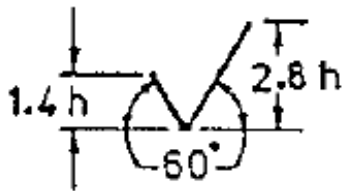
- Average deviation about the mean line measured



- Surface Roughness Measured by value

$$R_a = \frac{\sum^n A}{L}$$

Surface texture quality

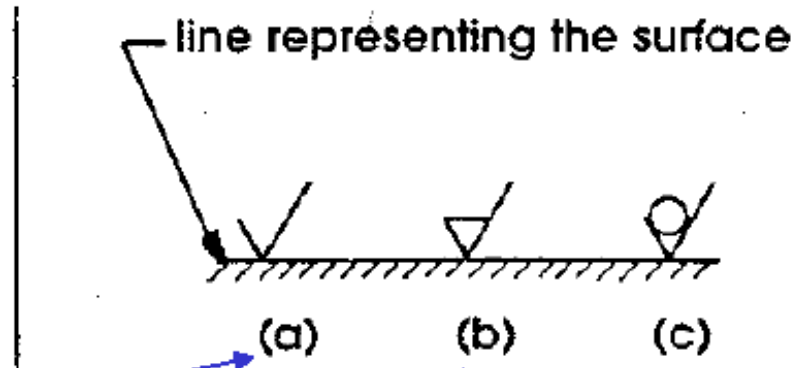


Surface texture

basic surface texture symbol

mandatory machining

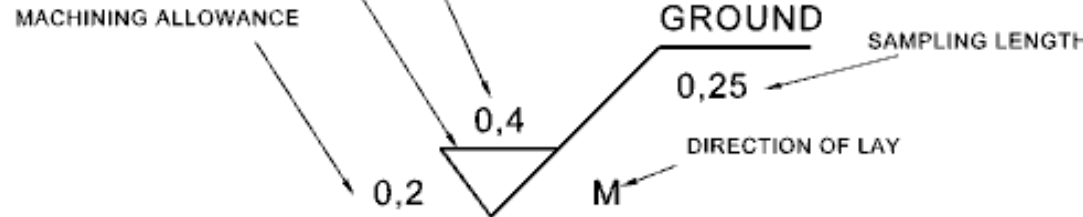
natural surface: no machining permitted



SURFACE FINISH IN Ra micro m

REQUIREMENT FOR MACHINING

SURFACE PRODUCTION METHOD



(μm)	0.025	0.05	0.1	0.2	0.4	0.8	1.6	3.2	6.3	12.5	25	50
(μinch)	1	2	4	8	16	32	63	125	250	500	1000	2000
N-Grade	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Finish	Ground Finishes			Smooth Turned			Medium Turned			Rough Machined		

Manufacture methods and roughness values

Roughness number, N	12	11	10	9	8	7	6	5	4	3	2	1
Roughness value, R_a (μm)	50	25	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.05	0.025
Super polishing												
Lapping												
Polishing												
Honing												
Grinding												
Boring, turning												
Die casting												
Reaming												
Broaching												
Cold rolling												
Drawing												
Extruding												
Milling												
Planing, shaping												
Drilling												
Forging												
Sawing												
Hot rolling												
Sand casting												
Flame cutting												

Conclusions

Today we reviewed:

- Representation of features and parts
- Importance of tolerance
- Geometric tolerances
- Surface finish and machining

- To be continued ... (next week)