



Lecture 09

DIMENSIONING AND TOLERANCES

Mechanical Engineering Graphics
MECH 211

Dimensioning rules

- Each feature of an object is dimensioned once and only once.
- Dimensions should be selected to suit the function of the object.
- Dimensions should be placed in the most descriptive view of the feature being dimensioned.
- Dimensions should specify only the size of a feature. The manufacturing method should only be specified if it is a mandatory design requirement.
- Angles shown on drawings as right angles are assumed to be 90 degrees unless otherwise specified, and they need not be dimensioned.

Dimensioning rules – Cont'd

- Dimensions should be located outside the boundaries of the object whenever possible.
- Dimension lines should be aligned and grouped where possible to promote clarity and uniform appearance.
- Crossed dimension lines should be avoided whenever possible. When dimension lines must cross, they should be unbroken.
- The space between the first dimension line and the object should be at least $\frac{3}{8}$ inch (10mm). The space between dimension lines should be at least $\frac{1}{4}$ inch (6mm).
- There should be a visible gap between the object and the origin of an extension line.

Dimensioning rules – Cont'd

- Extension lines should extend 1/8 inch (3mm) beyond the last dimension line.
- Extension lines should be broken if they cross or are close to arrowheads.
- Leader lines used to dimension circles or arcs should be radial.
- Dimensions should be oriented to be read from the bottom of the drawing.
- Diameters are dimensioned with a numerical value preceded by the diameter symbol.

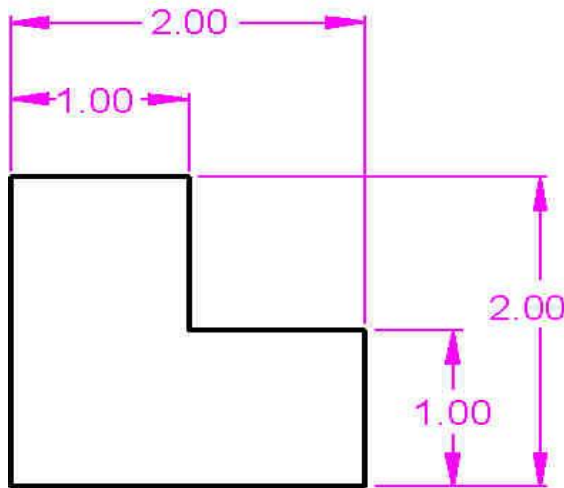
Dimensioning rules – Cont'd

- Concentric circles should be dimensioned in a longitudinal view whenever possible.
- Radii are dimensioned with a numerical value preceded by the radius symbol.
- When a dimension is given to the center of an arc or radius, a small cross is shown at the center.
- The depth of a blind hole may be specified in a note. The depth is measured from the surface of the object to the deepest point where the hole still measures a full diameter in width.
- Counterbored, spotfaced, or countersunk holes should be specified in a note.

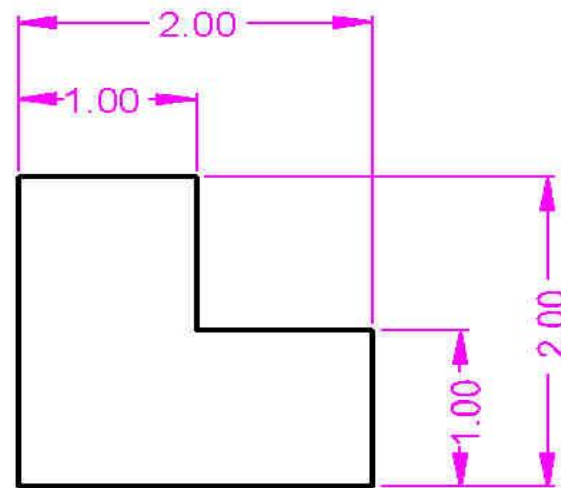
Dimension figures - Direction

Aligned and unidirectional dimensioning

- **Aligned Dimensions** have text placed parallel to the dimension line, with vertical dimensions read from the right of the drawing.
- **Unidirectional Dimensions** are read from bottom of page

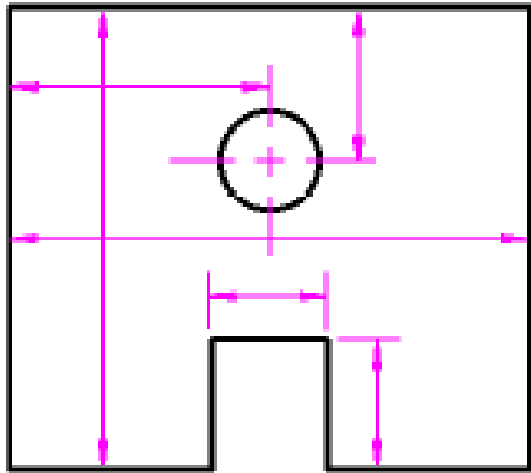


Unidirectional
Current standard

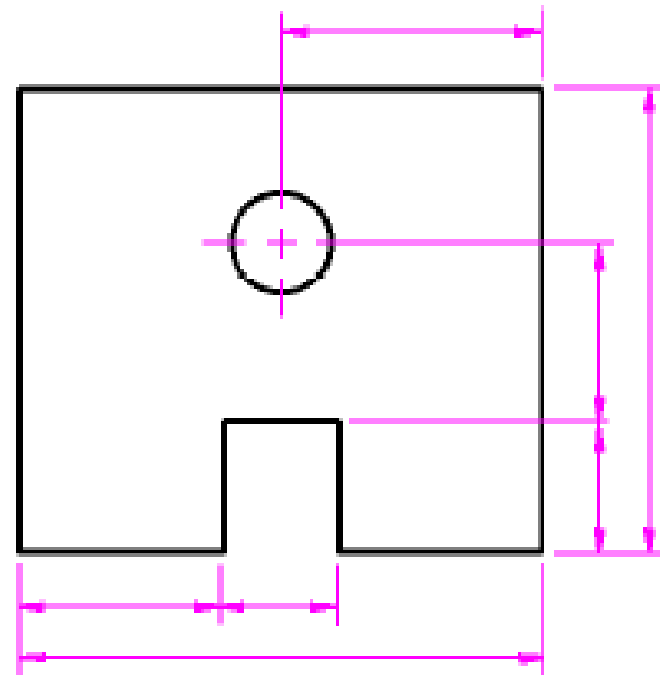


Aligned
Old standard

Dimension outside the view



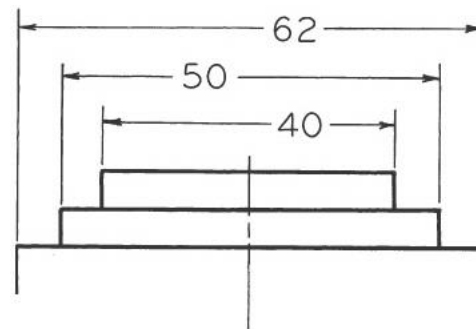
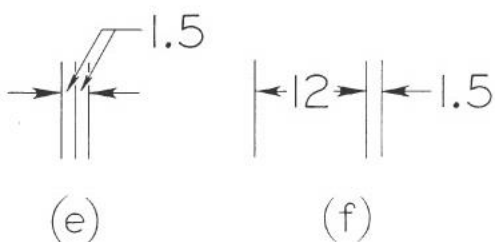
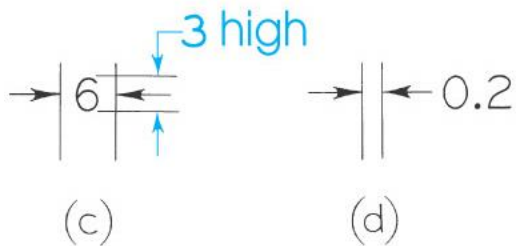
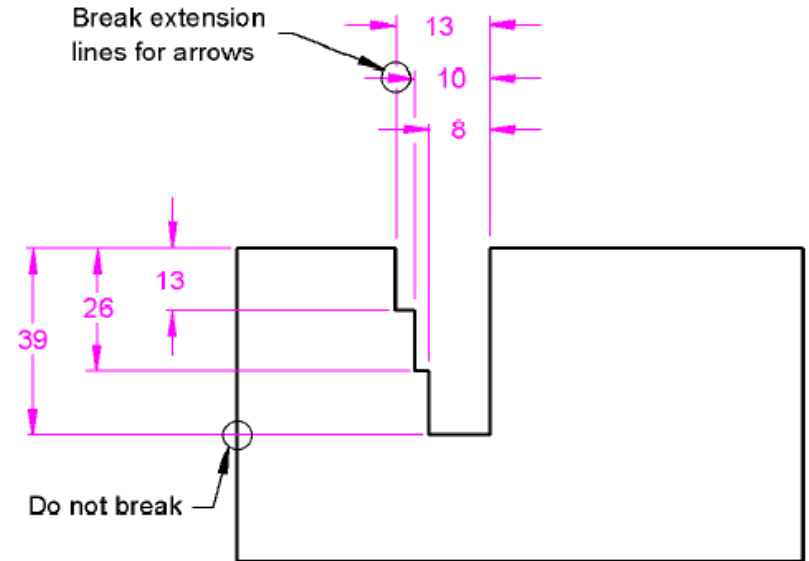
(A)
Avoid



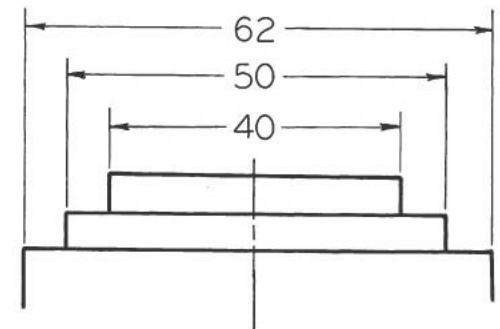
(B)
Good Practice

Extension line practice

- Use any of the four methods, as long as they are legible
- While grouping, stagger dimensions
- Do not break dimension lines for object lines, but for arrow heads



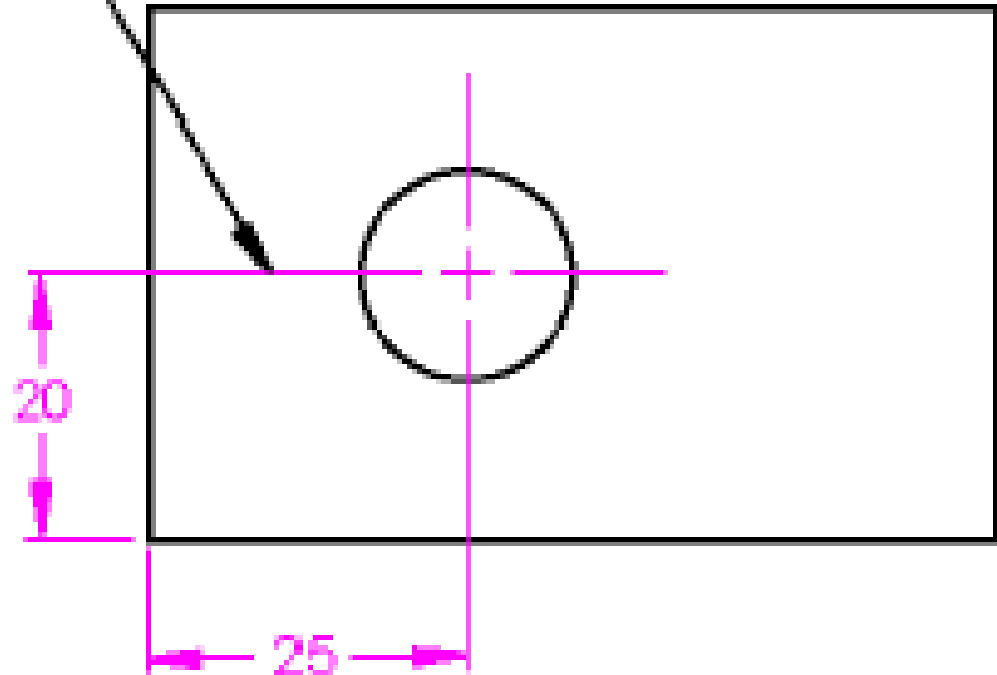
PREFERRED
(a)



POOR PRACTICE
(b)

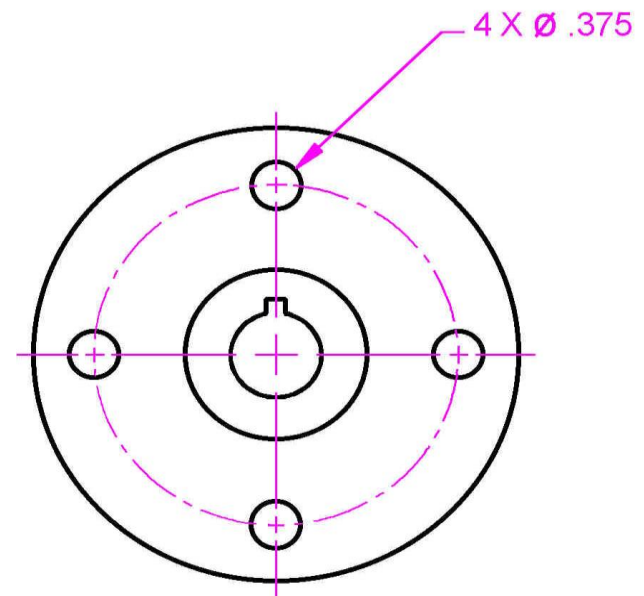
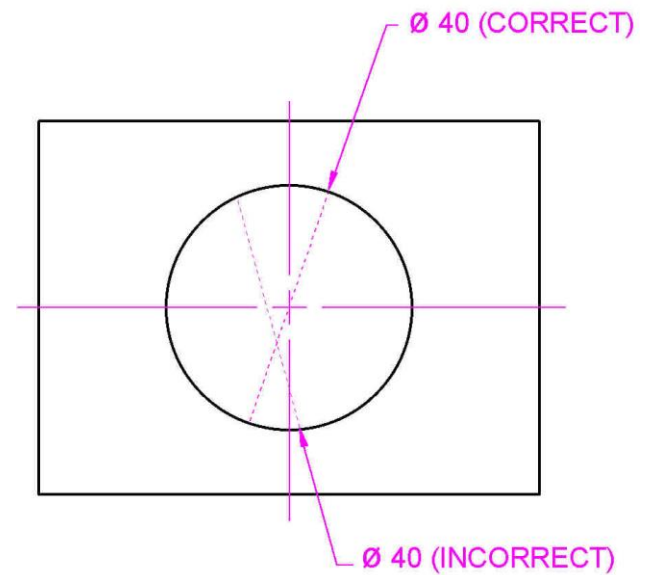
Center line practice

Centerline used as
an extension line



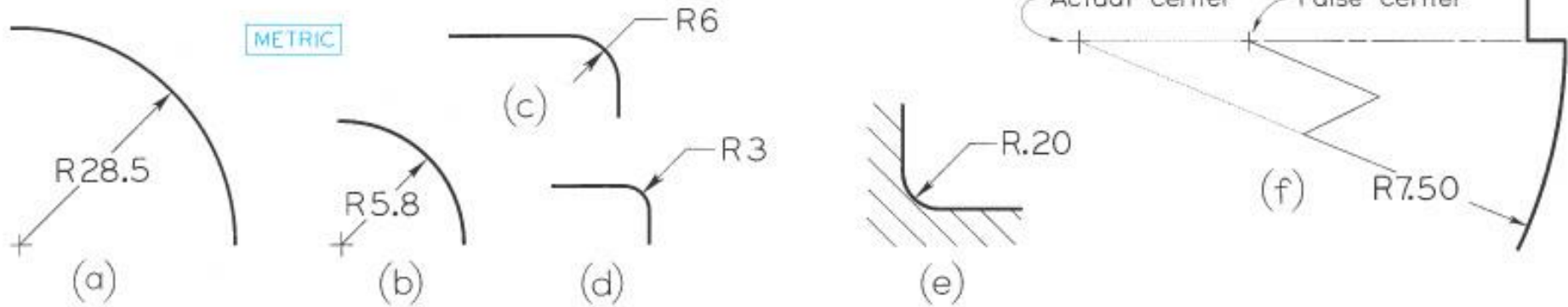
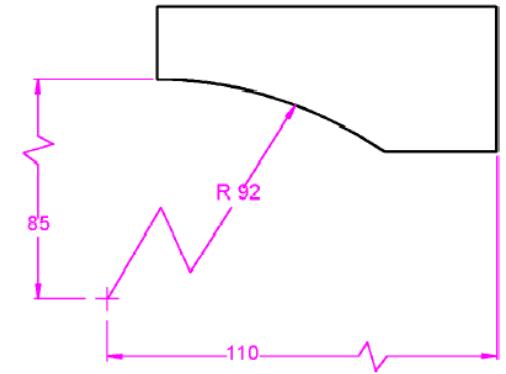
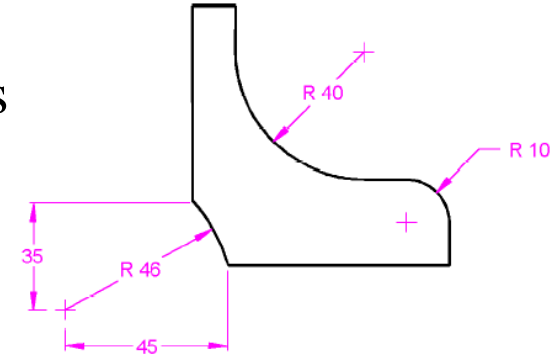
Radial and diametric dimensions

- More than half a circle:
diameter
- Leaders to point towards centre
of the circle or arc (Radial)
- Less than half a circle or arc:
radius



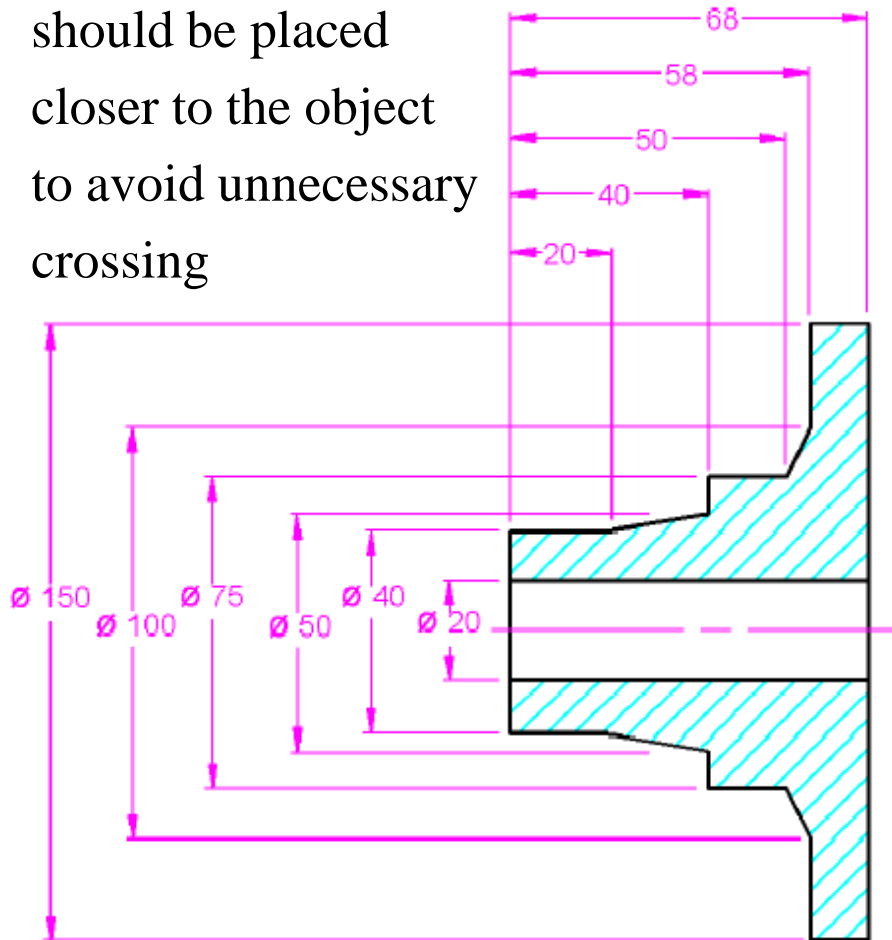
Dimensioning arcs

- Arc is dimensioned in a view where true shape is seen
- If space is available leader and the value is located inside the arc. If not numeral alone or including leader is moved out
- Cross is indicated with or without dimensions for centre of all arcs except small and unimportant radii
- For long radius, false center with jogged leader can be used

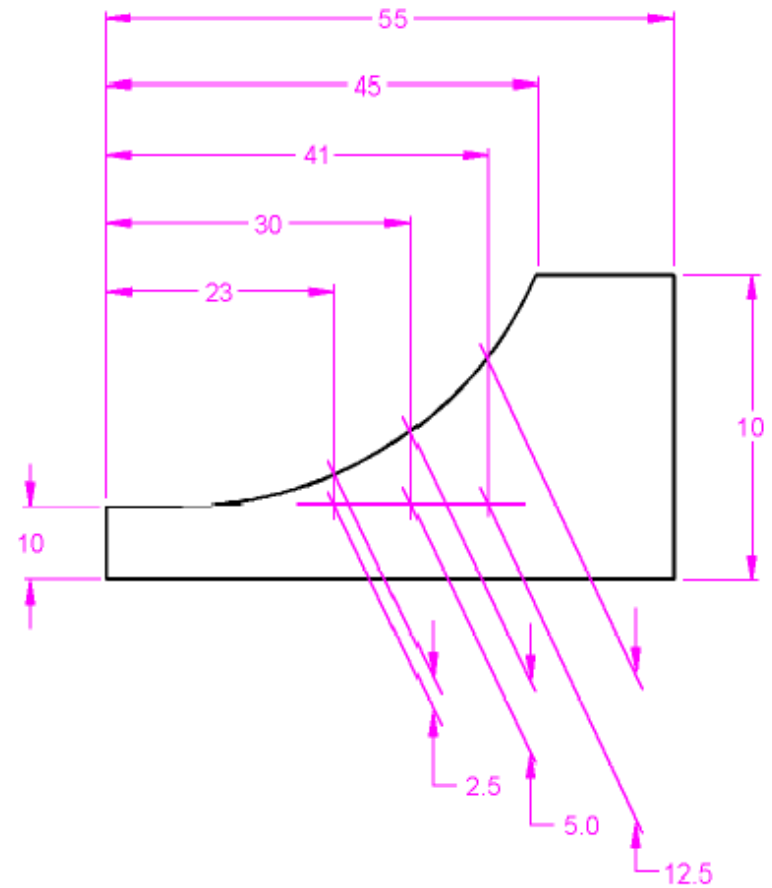


Dimensioning chained features

- smaller dimension should be placed closer to the object to avoid unnecessary crossing



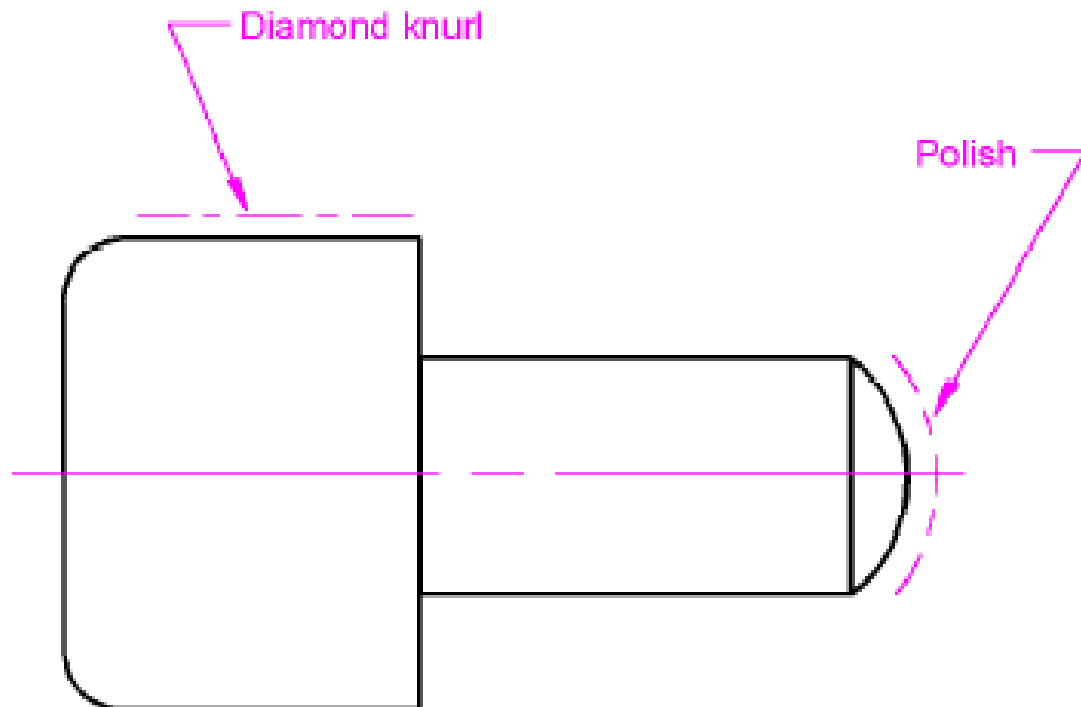
Staggering dimension text



Aligning dimension lines

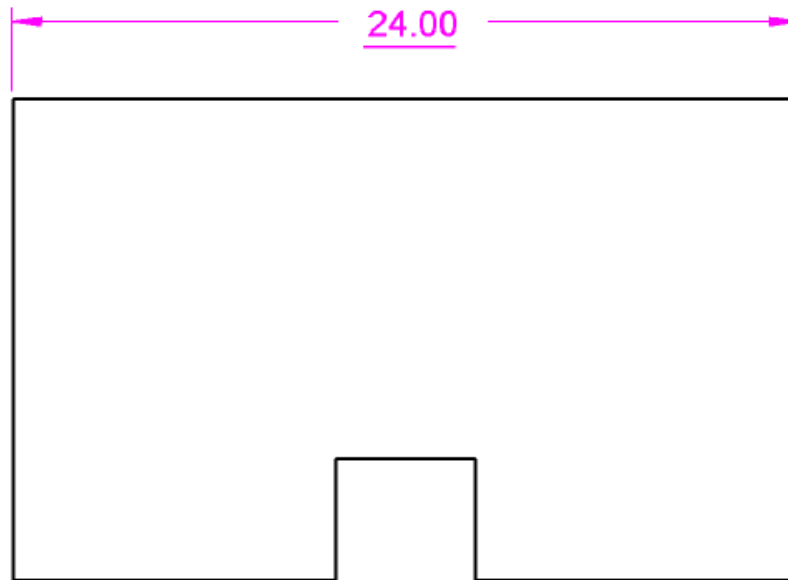
Detailed explanations

- Extension lines and line indicators are used to detail manufacturing requirements



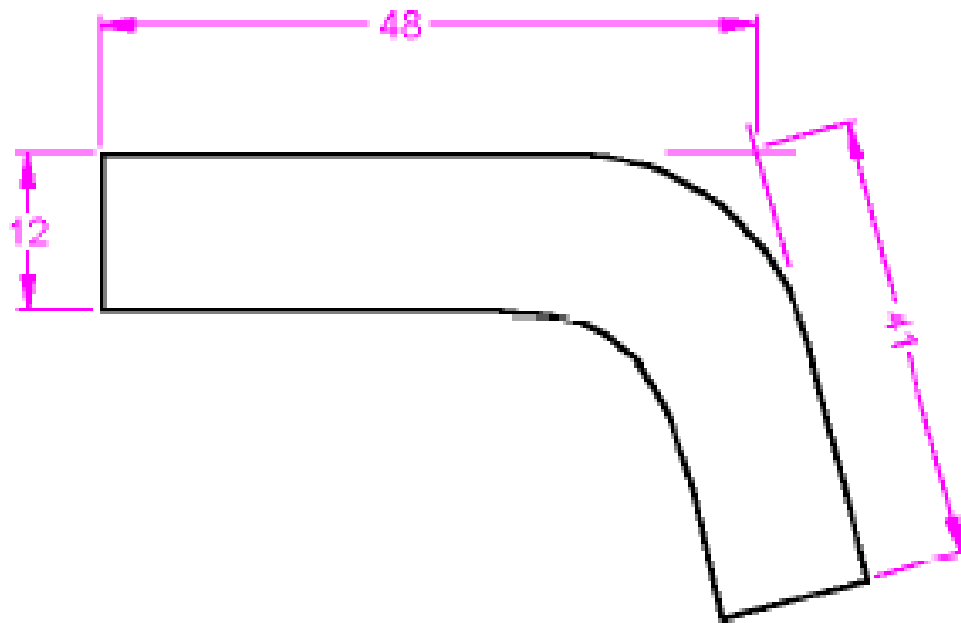
Not to scale dimensioning

- All features in drawings are scaled accordingly
- Not-scaled features could be also represented but also indicated with an underline



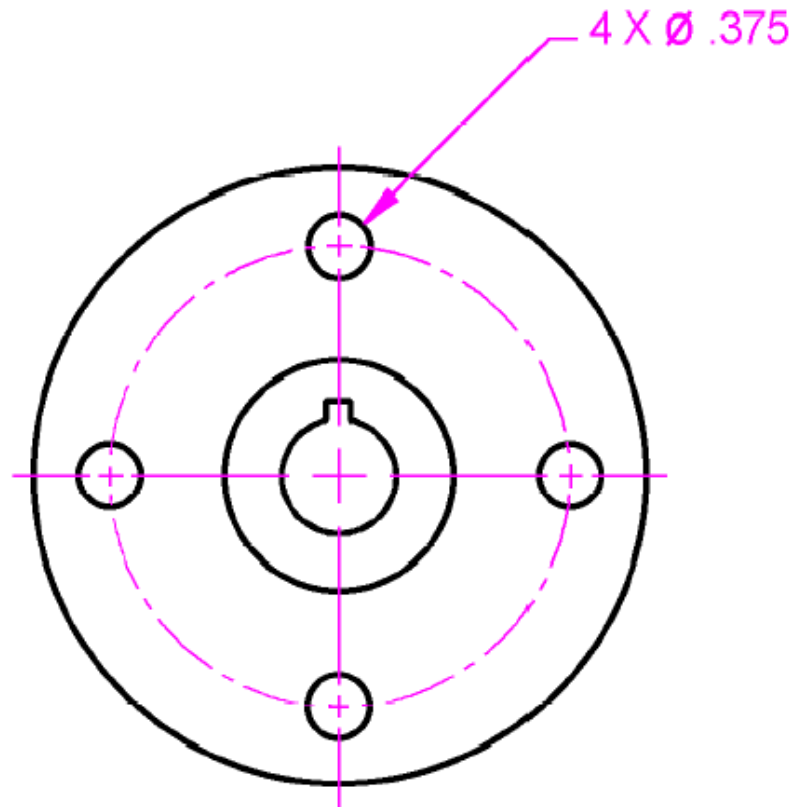
Reference for the extension line

- Dimensioning is always performed between crisp surfaces
- Sometimes, such surfaces are not available and the dimensioning is given to facilitate the manufacturing process, extension lines with reference marks are used



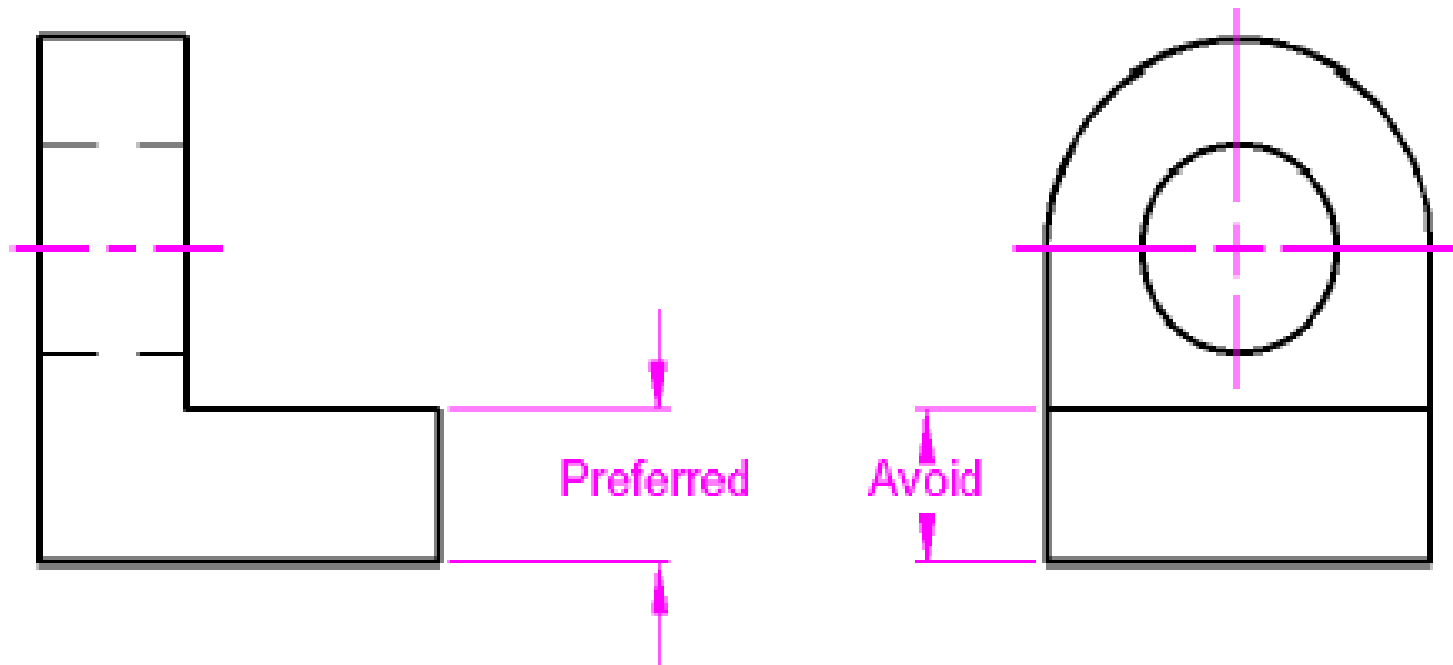
General dimensioning

- Holes should be dimensioned in the view that they are best seen



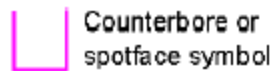
General dimensioning – Cont'd

- Features should be dimensioned in the views that are best seen



General dimensioning – Cont'd

- Do not draw a view/section for a feature that could be indicated by a symbol



Counterbore or spotface symbol



Countersink symbol



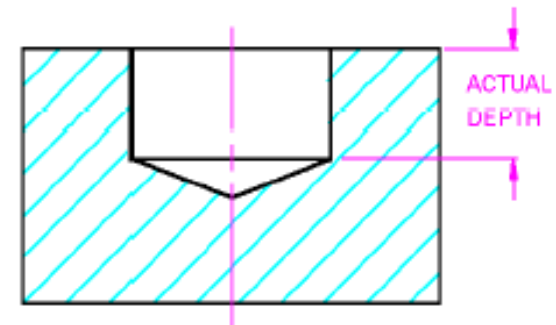
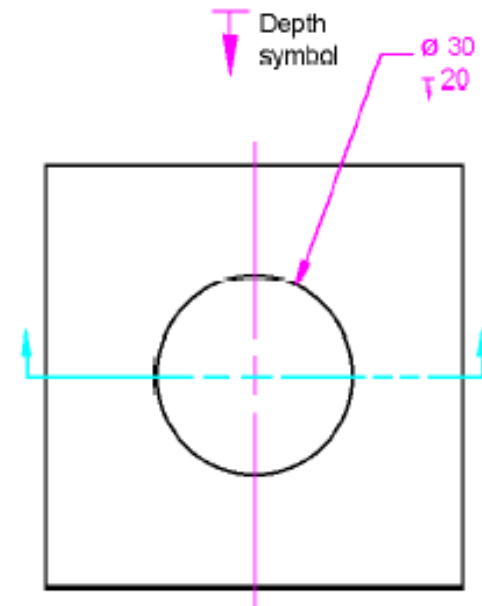
Diameter symbol



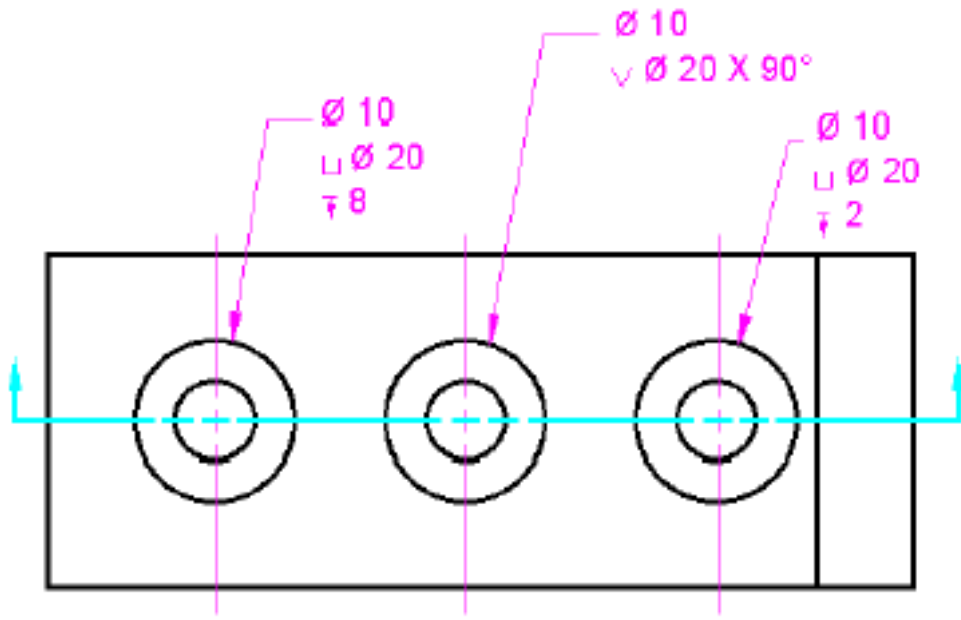
Square symbol



Depth symbol



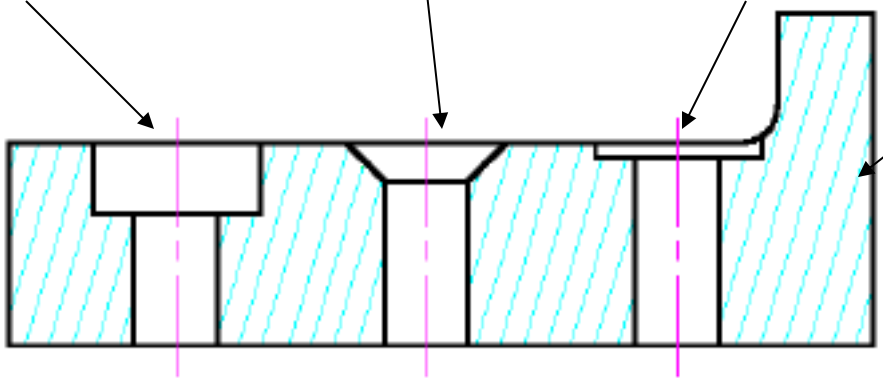
General dimensioning – Cont'd



Counterbore

Countersink

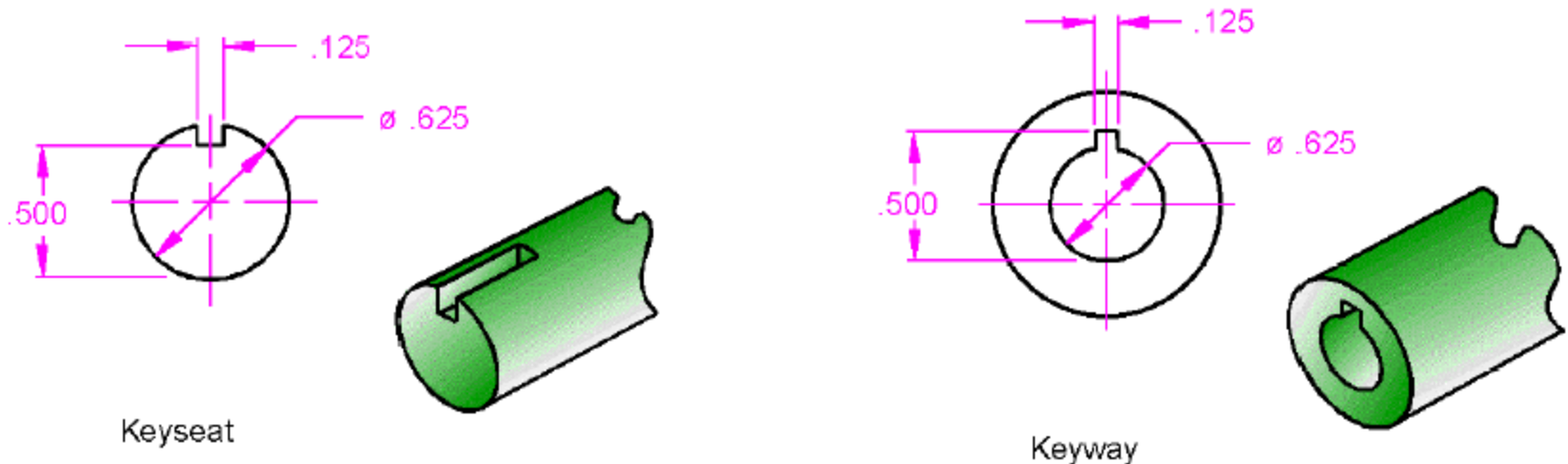
Spotface



Section view is needless as symbols in the topview means this

General dimensioning – Cont'd

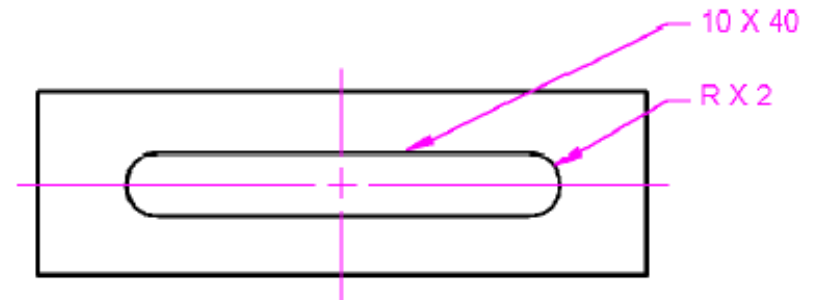
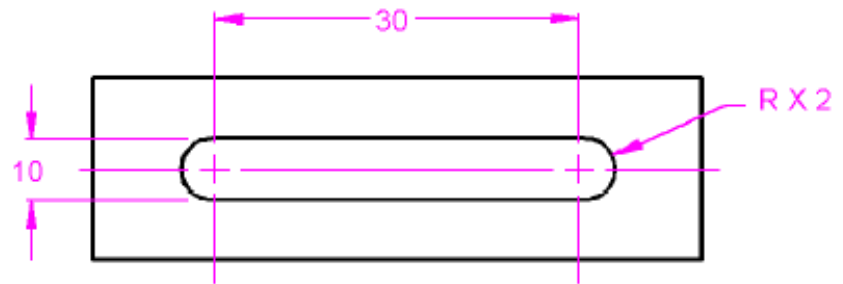
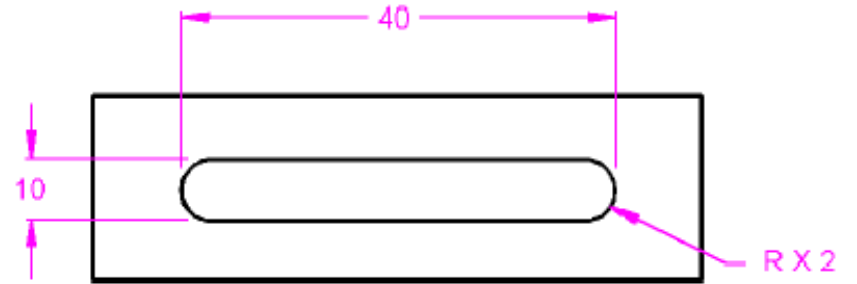
- Dimension keyseats from the bottom of the keyseat to opposite end of the shaft
- For key seat, from top of keyway to bottom of hole



Keyseat and keyway

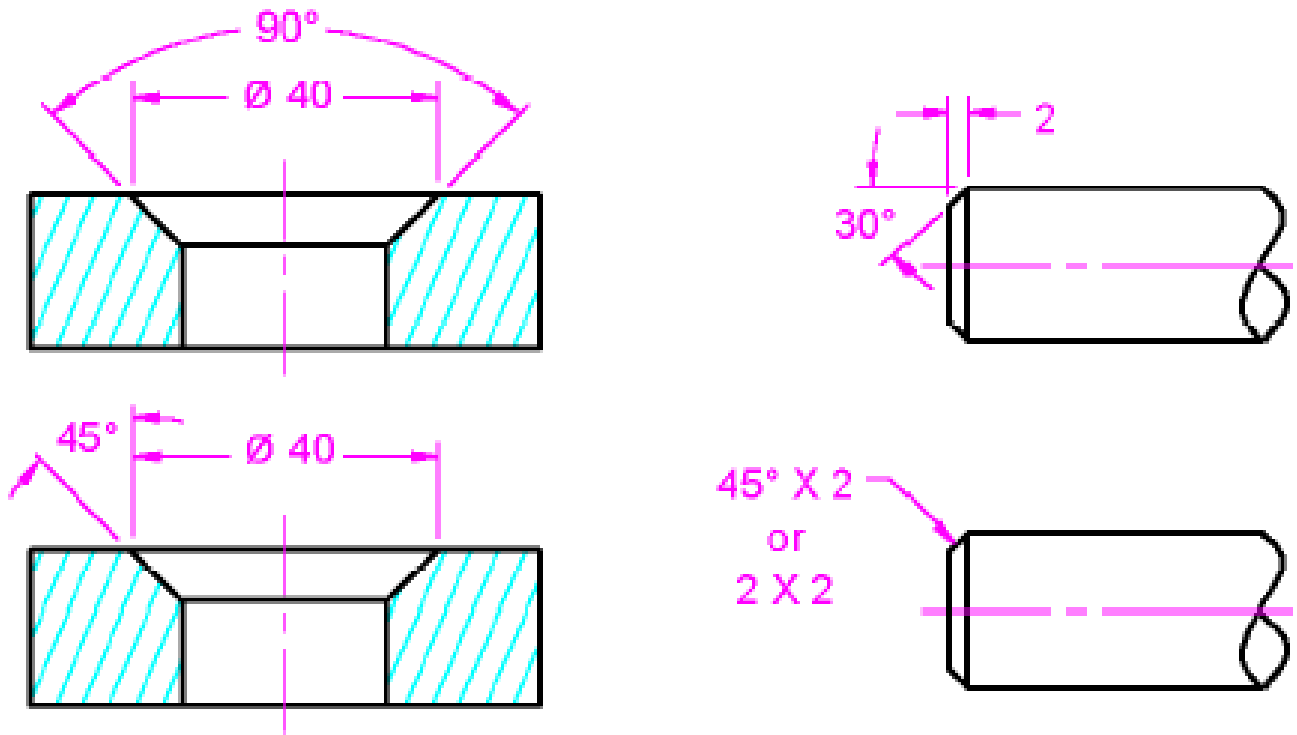
General dimensioning – Cont'd

- By giving centre to centre distances and radii of ends
- One radius dimension is only needed, but number of places need to be mentioned



Slot cuts

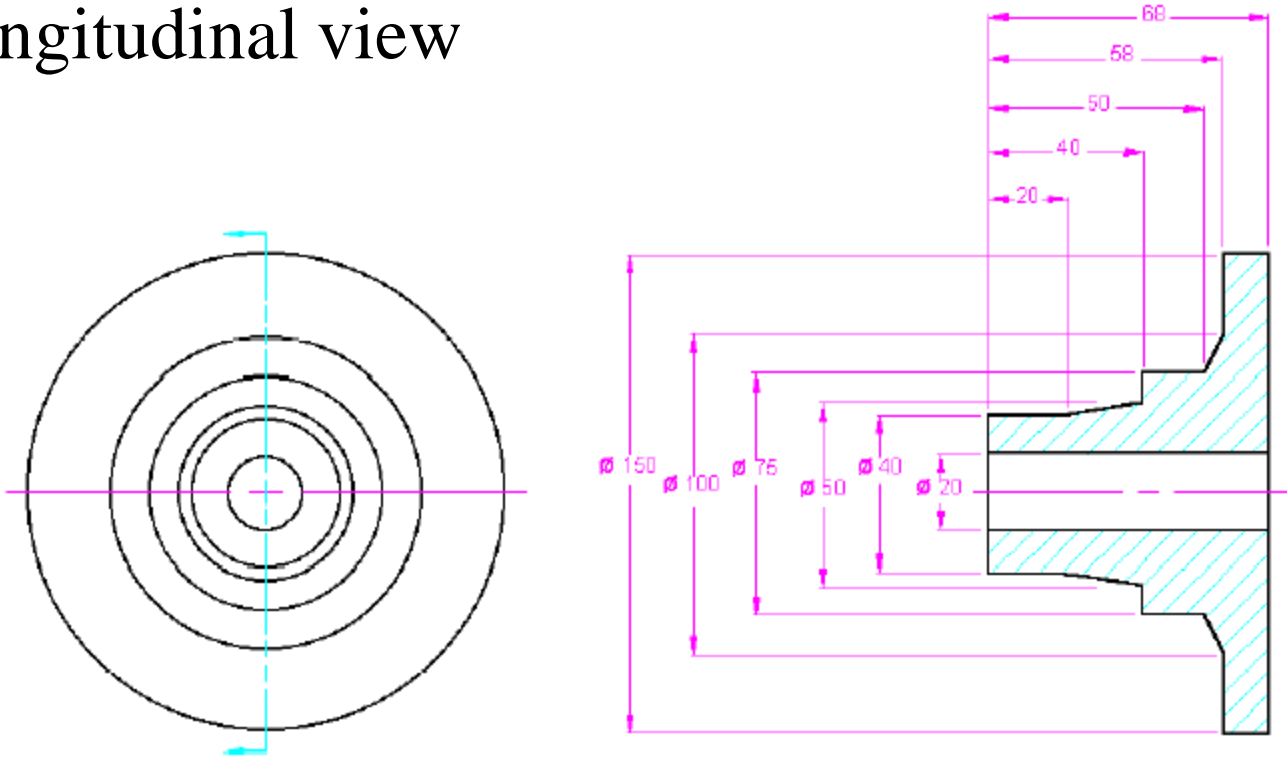
General dimensioning – Cont'd



Chamfers

General dimensioning – Cont'd

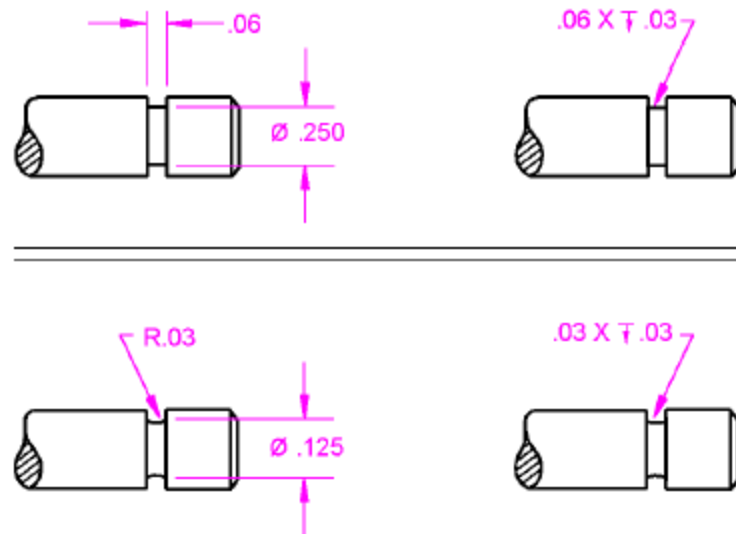
- Dimensioned in the longitudinal view



Concentric circles

General dimensioning – Cont'd

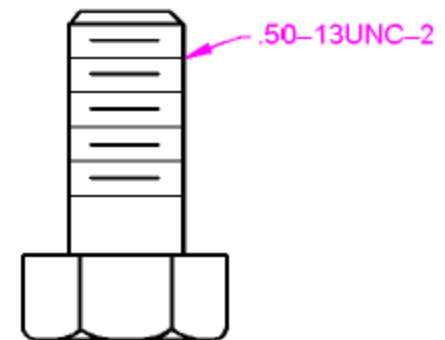
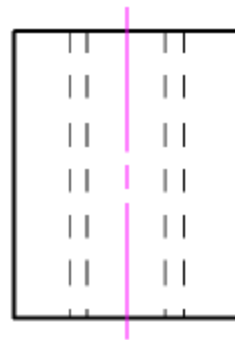
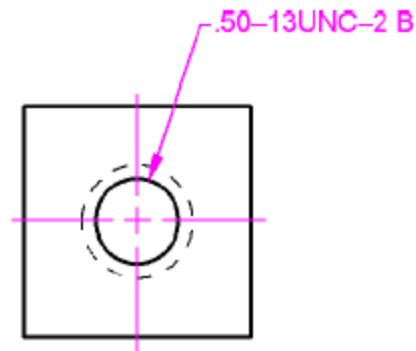
- Dimensioned with local notes
- Or by showing the dimensions of both the depth of undercut and the distance



Grooves

General dimensioning – Cont'd

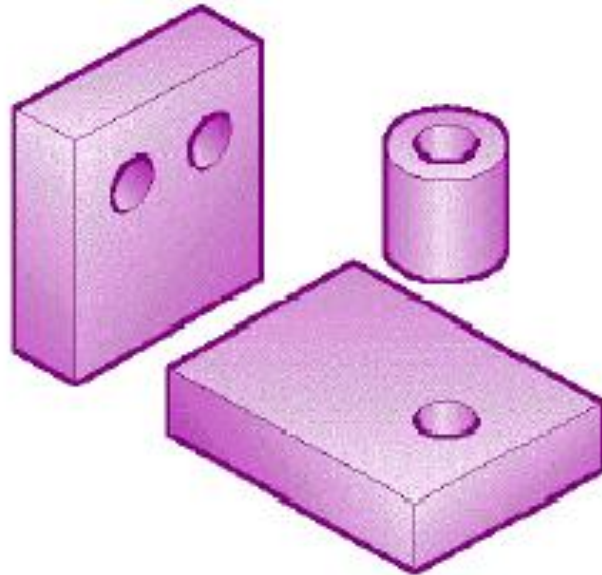
- Threads are dimensioned with local notes
- Internal or tapped threads on the circular view
- External threads on the longitudinal view



Threads

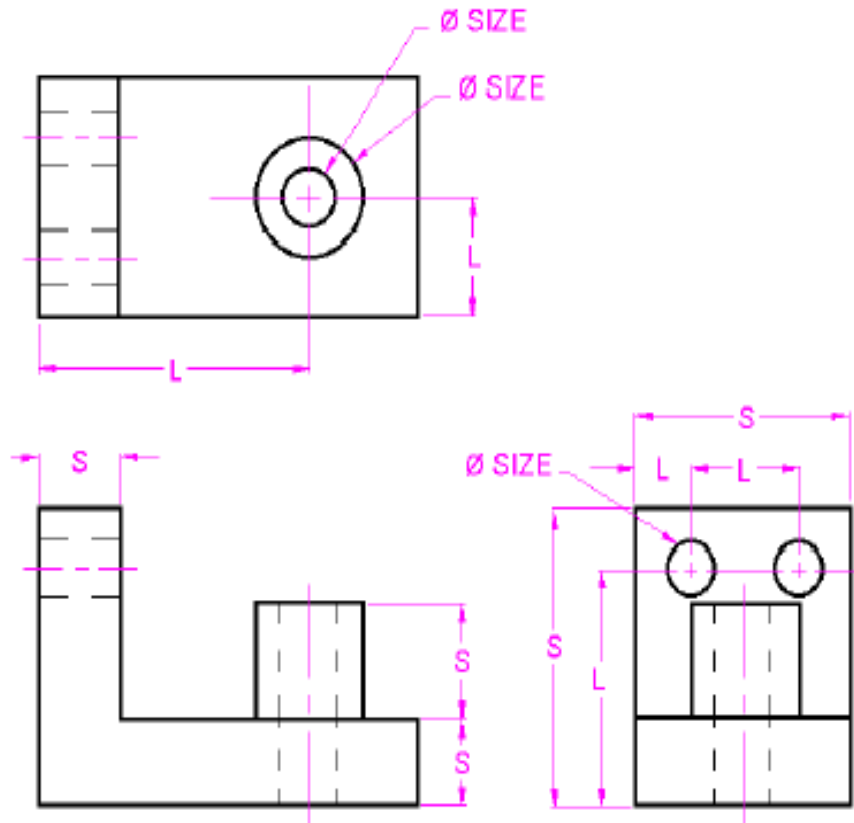
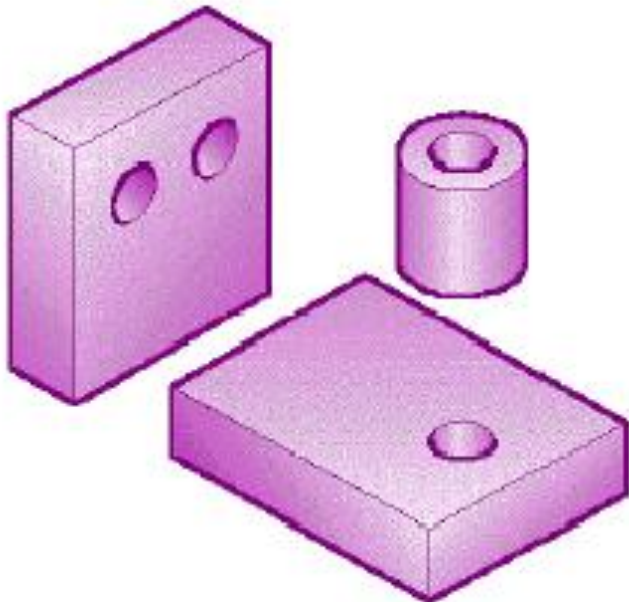
Size Vs. Location

- Both size and location dimensions have to be provided to avoid any confusion



Size Vs. Location

- Both size and location dimensions have to be provided to avoid any confusion



Reminder

- Each feature of an object is dimensioned once and only once
- The location and/or size dimensions for a feature should be placed in the view in which that feature is most clearly seen i.e. where its shape description is most complete
- Any dimension specified should correspond to a range of dimensions in the final product, i.e. each dimension should include an appropriate tolerance

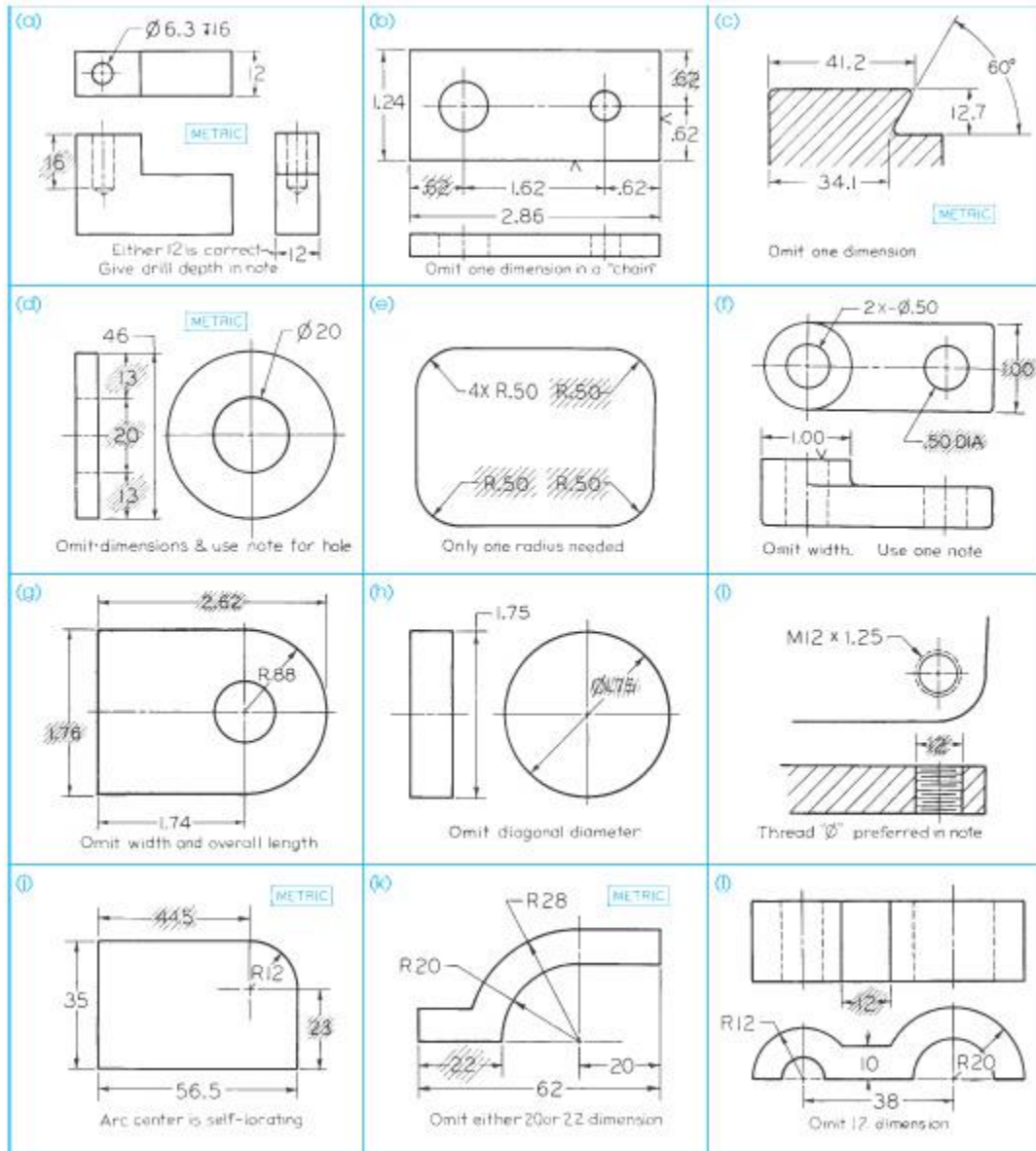
Reminder

- Dimension lines should never coincide with object lines or other extension lines
- Dimension lines should be unbroken except for the number between the arrowheads
- There should be a visible gap between the object and the origin of an extension line
- Crossing of dimension lines should be avoided wherever possible

Reminder

- Dimensions should reference object lines rather than hidden lines
- Dimensions should be placed in spaces as close as possible to their point of application
- When dimensions are "nested", the smaller dimension should be placed closer to the object to avoid unnecessary crossing
- Dimensions should be located outside the boundaries of the object wherever possible

Superfluous dimensions



What is Important?

- Understanding of tolerances
- Selection and calculations
- Prescription of tolerances
- *Tolerance of a size: the difference between the maximum and the minimum allowed size of the specific dimension*

Nomenclature

- **Nominal Size** – The general size (used for general identification of part)
- **Basic Size** – Theoretical size (size from which limits are worked out)
- **Actual Size** – Measured size of the actual part
- **Limits** – the max and min sizes shown by tolerances
- **Allowance** – for mating parts – min clearance or max interference
- **Tolerance** - total allowable variance

Nomenclature

- **Maximum material condition (MMC)** – where part contains maximum amount of material
- **Least material condition (LMC)** – where part contains minimum amount of material
- **Clearance fit** – condition of fit that enables space between mating parts
- **Interference fit** – condition of fit that enables no space between mating parts
- **Transition fit** – clearance or interference fit

Tolerance representation

- Direct limits

(limit dimensioning)

- Tolerance value

(plus or minus dim)

- Unilateral Tolerances

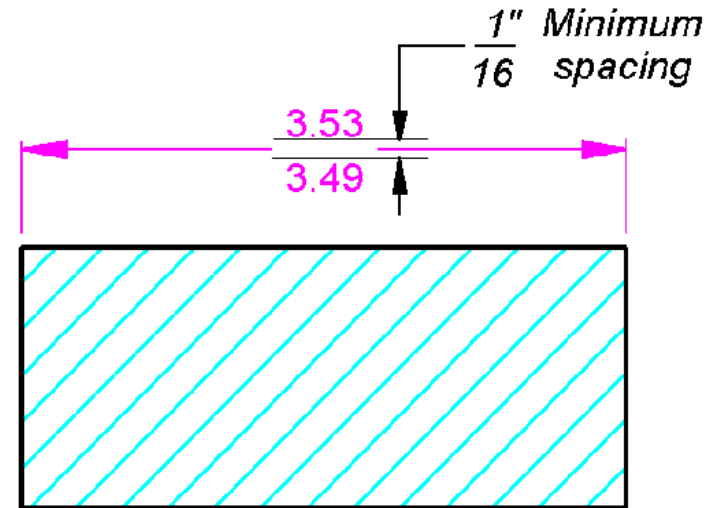
(only in one direction from basic size)

- Specific note

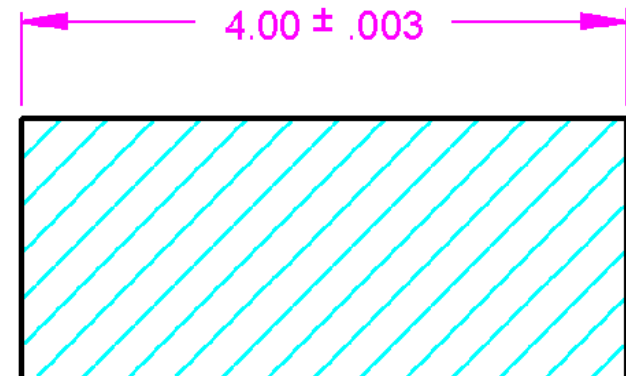
*(The * dimensions $\phi 2_{\pm 0.001}$)*

- General note

(All diameters $\phi 2_{\pm 0.001}$)

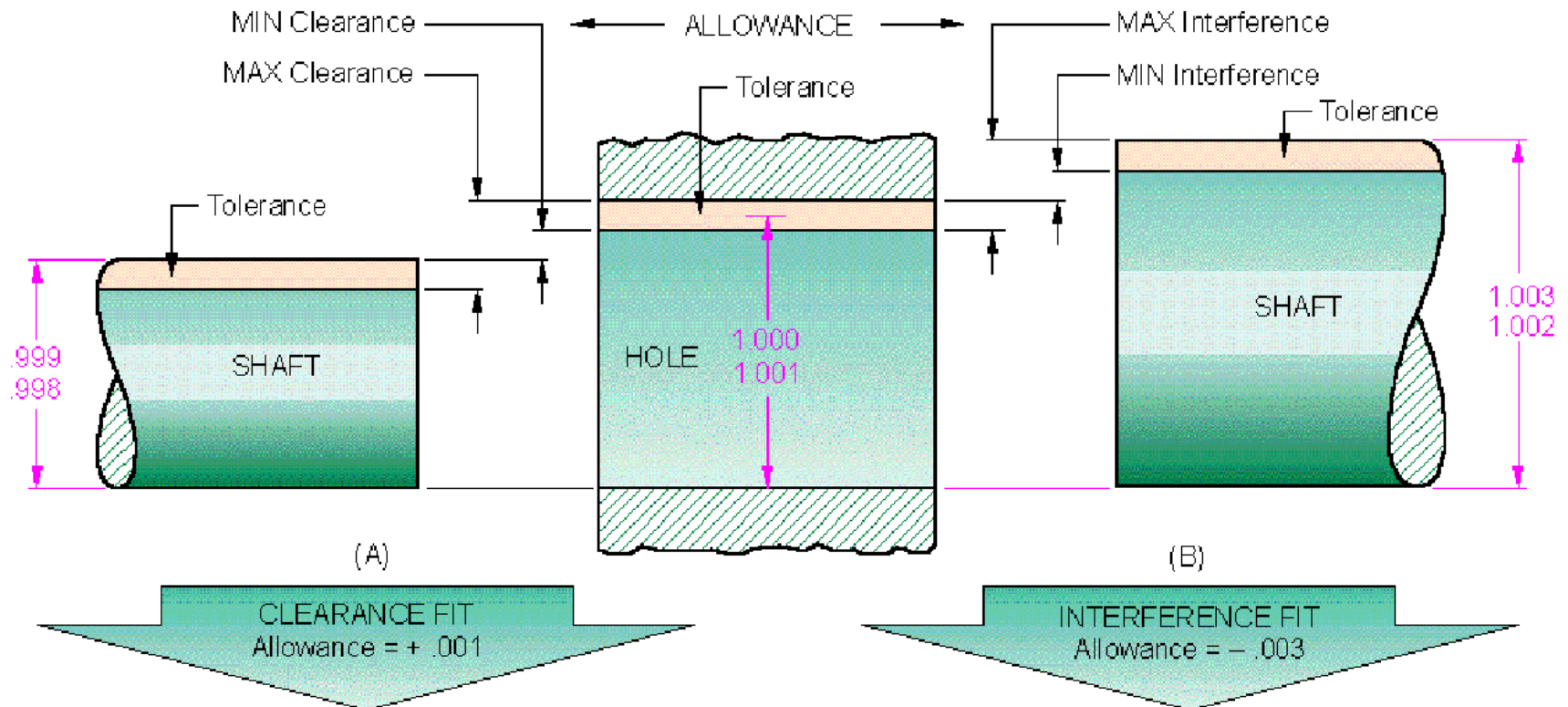


(A) Direct limits



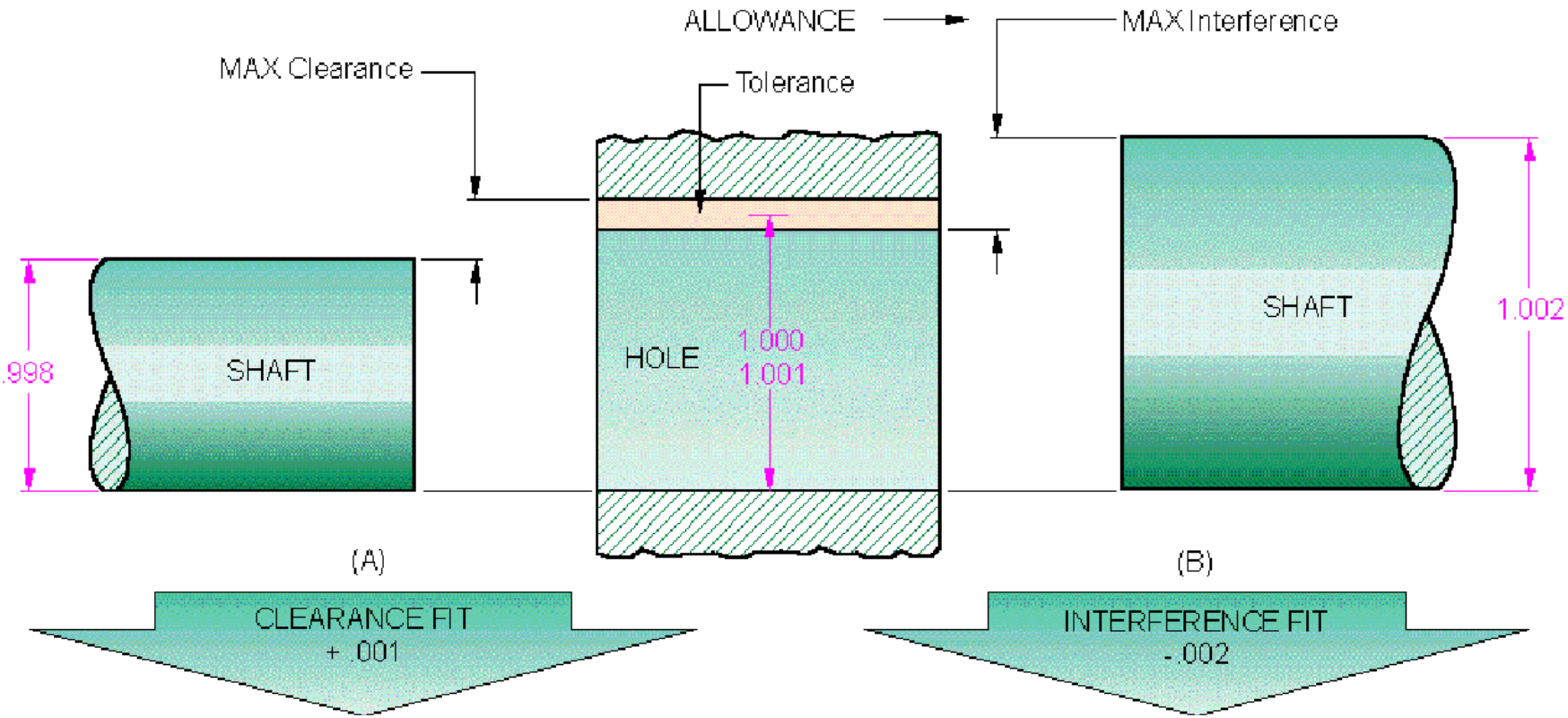
(B) Tolerance values

Clearance and interference fits



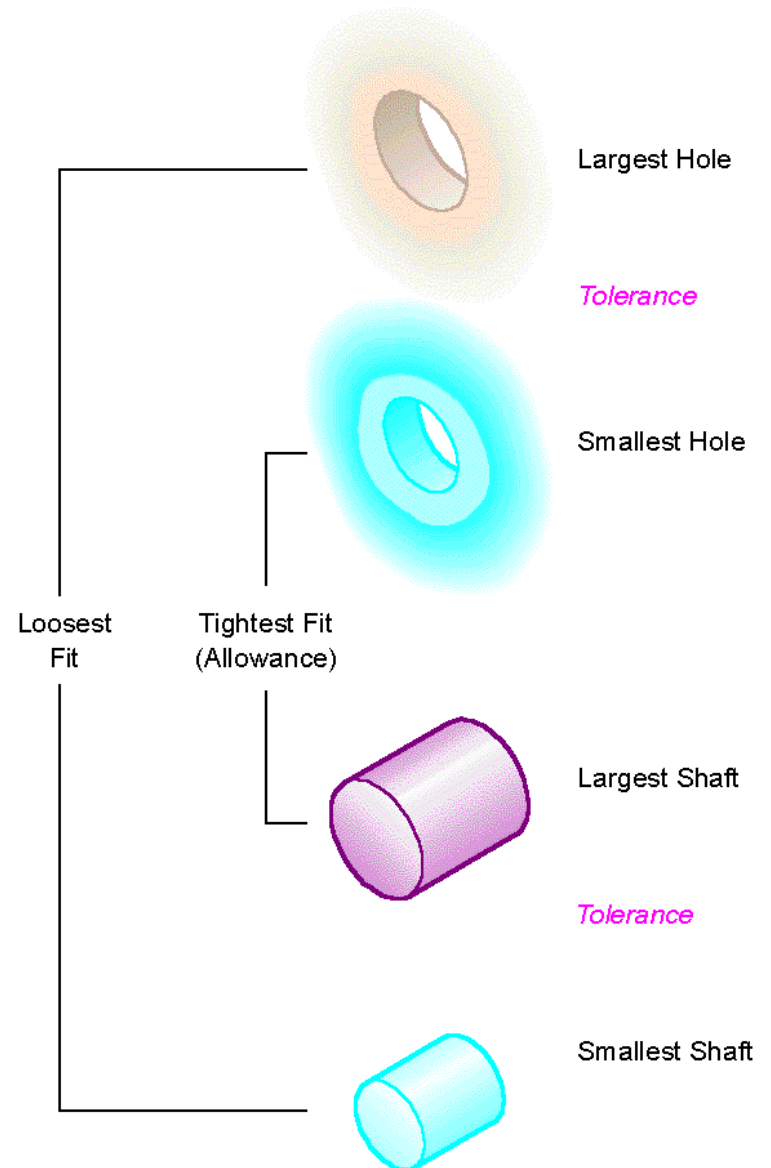
Allowance always equals smallest hole minus largest shaft

Transition fit



How to determine fits?

- Evaluate the allowance and the interference

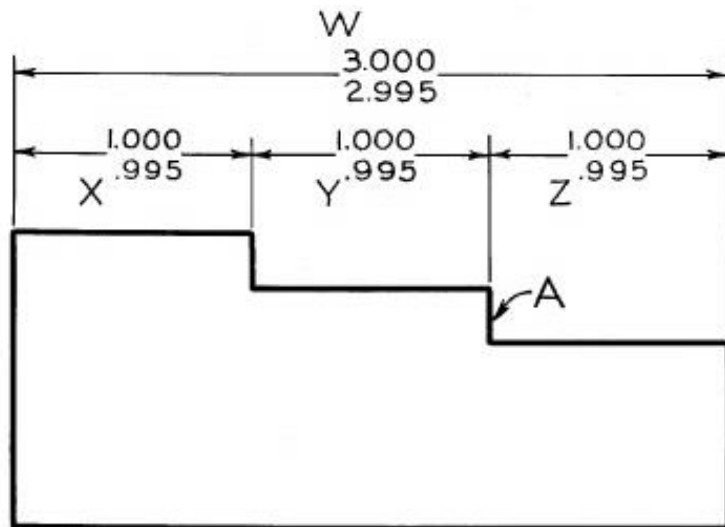


Functional dimensioning

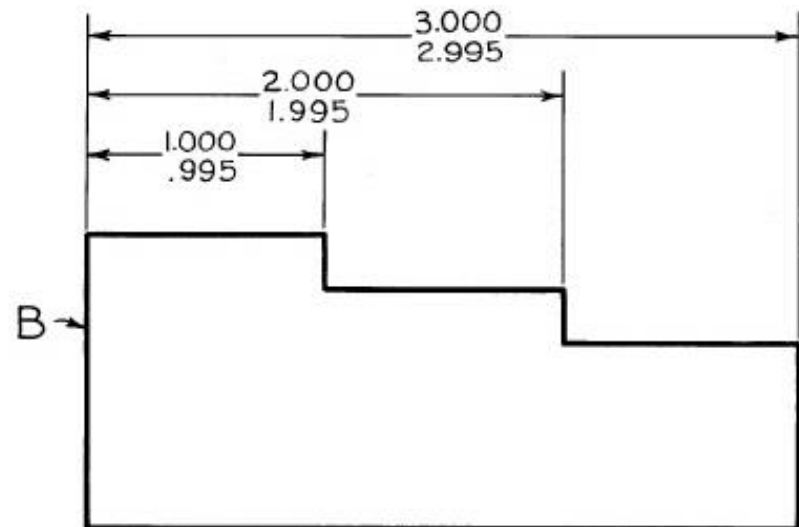
- Functional dimensioning begins with tolerancing the most important features
- The functionality of the assembly has to be very clearly established by the designer
- The assembly procedure as well as the manufacturing processes involved in producing the part must be also clear to the designer
- Tolerances should be as “coarse” as possible and still permit satisfactory use of part – Why?

Tolerance Stack-up

- Tolerances taken in the same direction from one point of reference are additive – **tolerances stack-up** or **accumulation of tolerance**
- Tolerance stack-up can be eliminated by careful selection and placement of dimensions
- If Z not given, it will be governed by both X and Y (.01 instead of intended tolerance of .005)

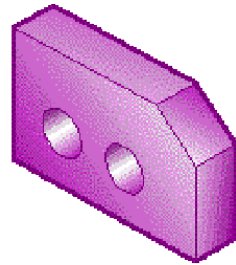


(a) CUMULATIVE TOLERANCES

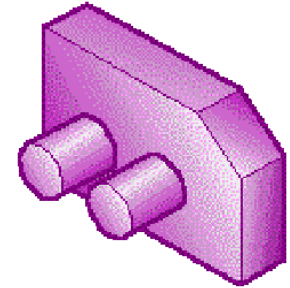
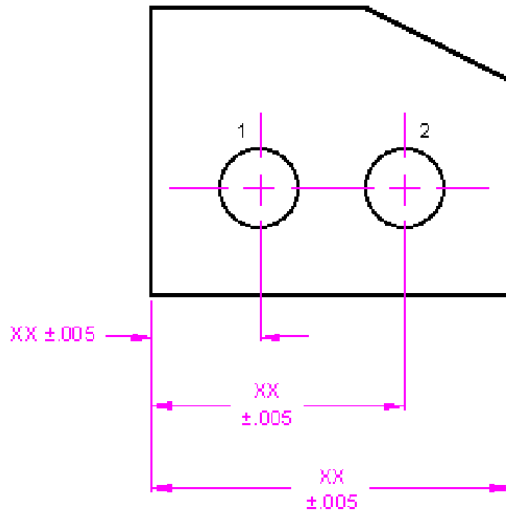


(b) BASE-LINE DIMENSIONING

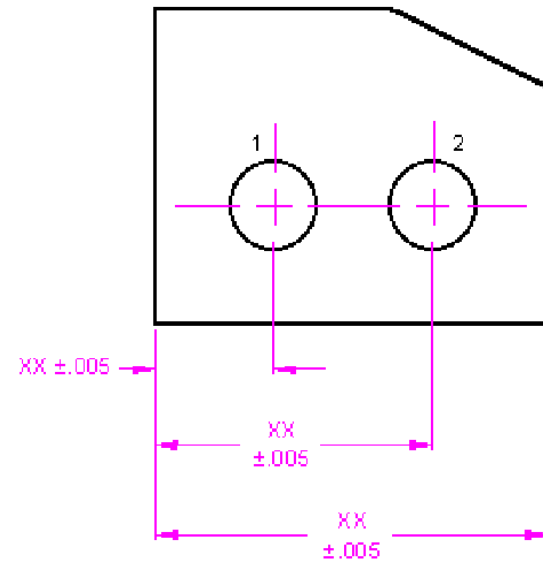
Tolerance Stack-up



PART A

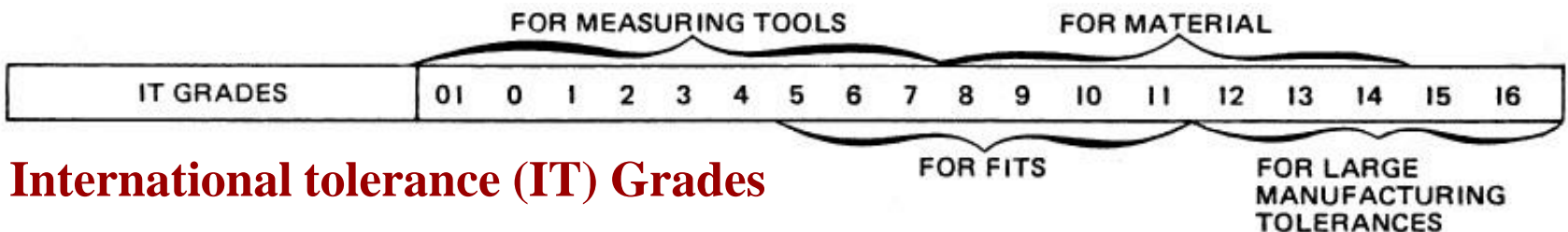
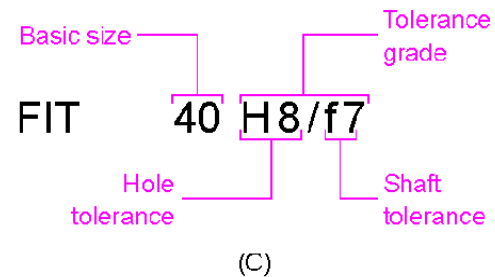
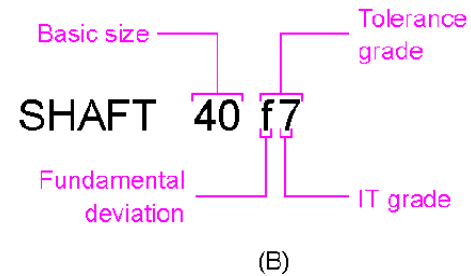
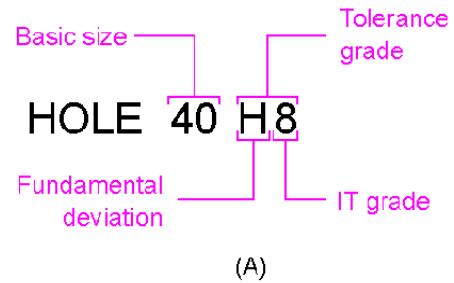
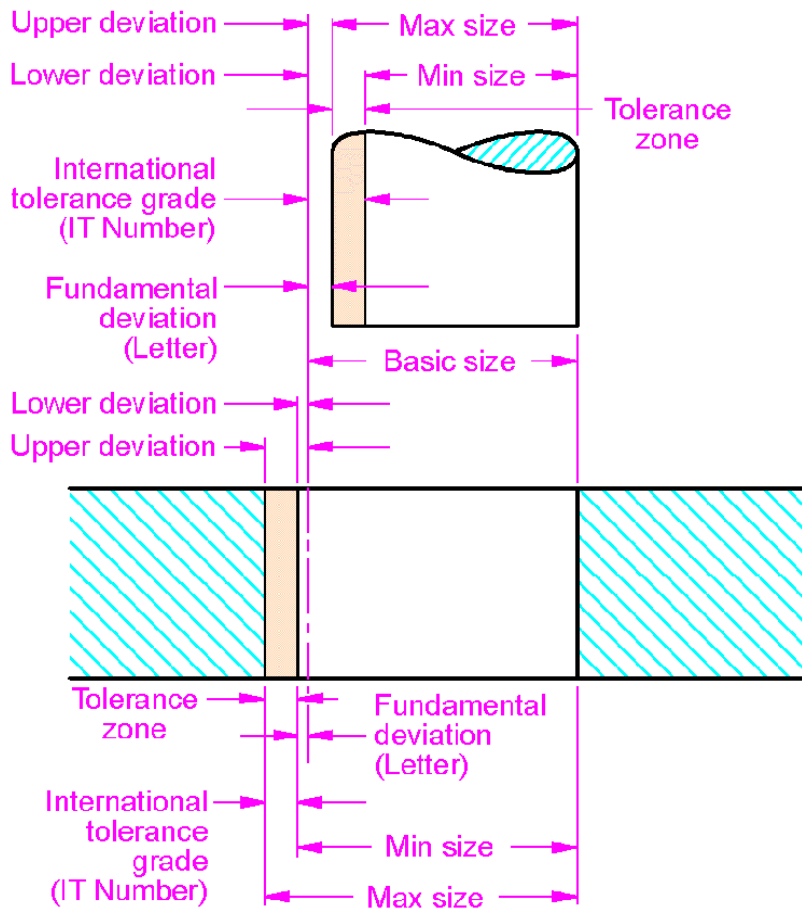


PART B



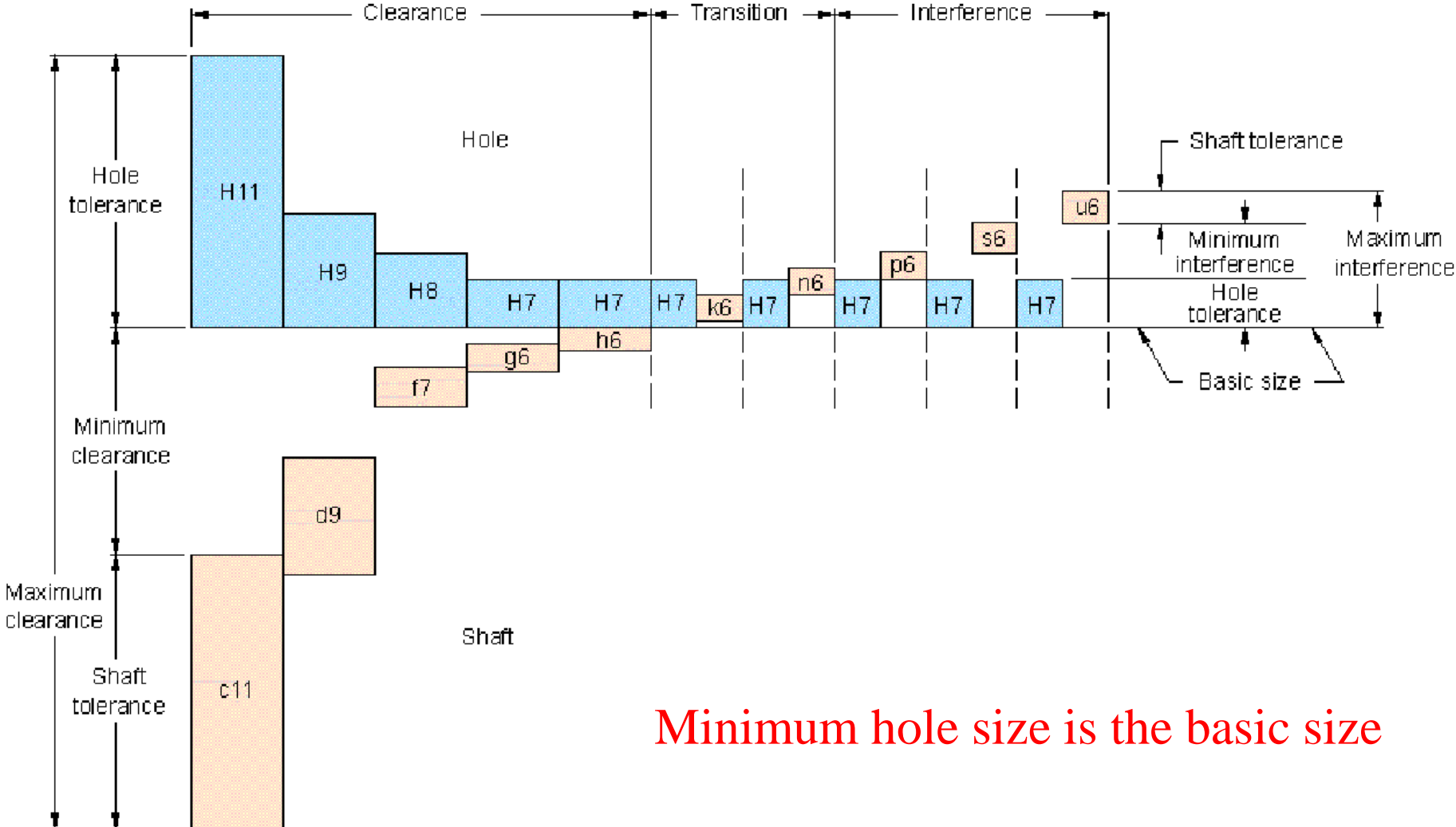
Dimensioning with respect to the base base would help

Tolerancing in ISO



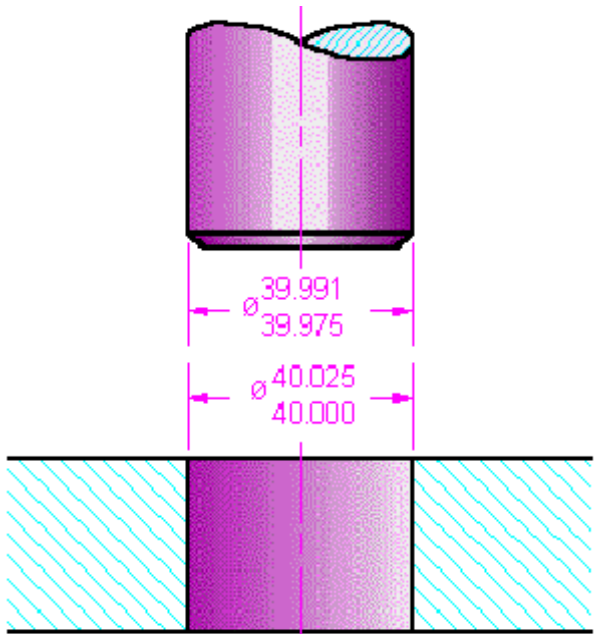
International tolerance (IT) Grades

Metric preferred hole based system of fits



Minimum hole size is the basic size

Limit form vs. note form tolerancing



Method 1
Limit Form

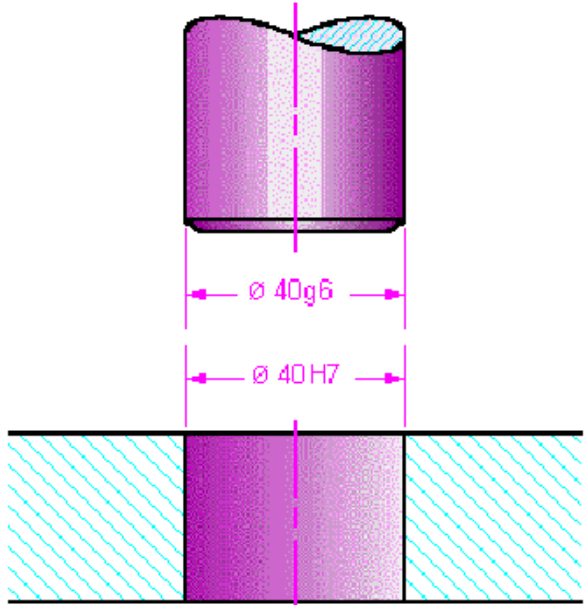
<table border="1"> <tr><th>Hole</th></tr> <tr><td>40.025</td></tr> <tr><td>40.000</td></tr> <tr><td><hr style="width: 50%; margin: 0;"/></td></tr> <tr><td>.025</td></tr> </table> <p>Hole tolerance</p>	Hole	40.025	40.000	<hr style="width: 50%; margin: 0;"/>	.025	<table border="1"> <tr><th>Shaft</th></tr> <tr><td>39.991</td></tr> <tr><td>39.975</td></tr> <tr><td><hr style="width: 50%; margin: 0;"/></td></tr> <tr><td>.016</td></tr> </table> <p>Shaft tolerance</p>	Shaft	39.991	39.975	<hr style="width: 50%; margin: 0;"/>	.016
Hole											
40.025											
40.000											
<hr style="width: 50%; margin: 0;"/>											
.025											
Shaft											
39.991											
39.975											
<hr style="width: 50%; margin: 0;"/>											
.016											

Hole Tolerance =
.025

Shaft Tolerance =
.016

Loosest fit =
40.025 - 39.975 =
.050

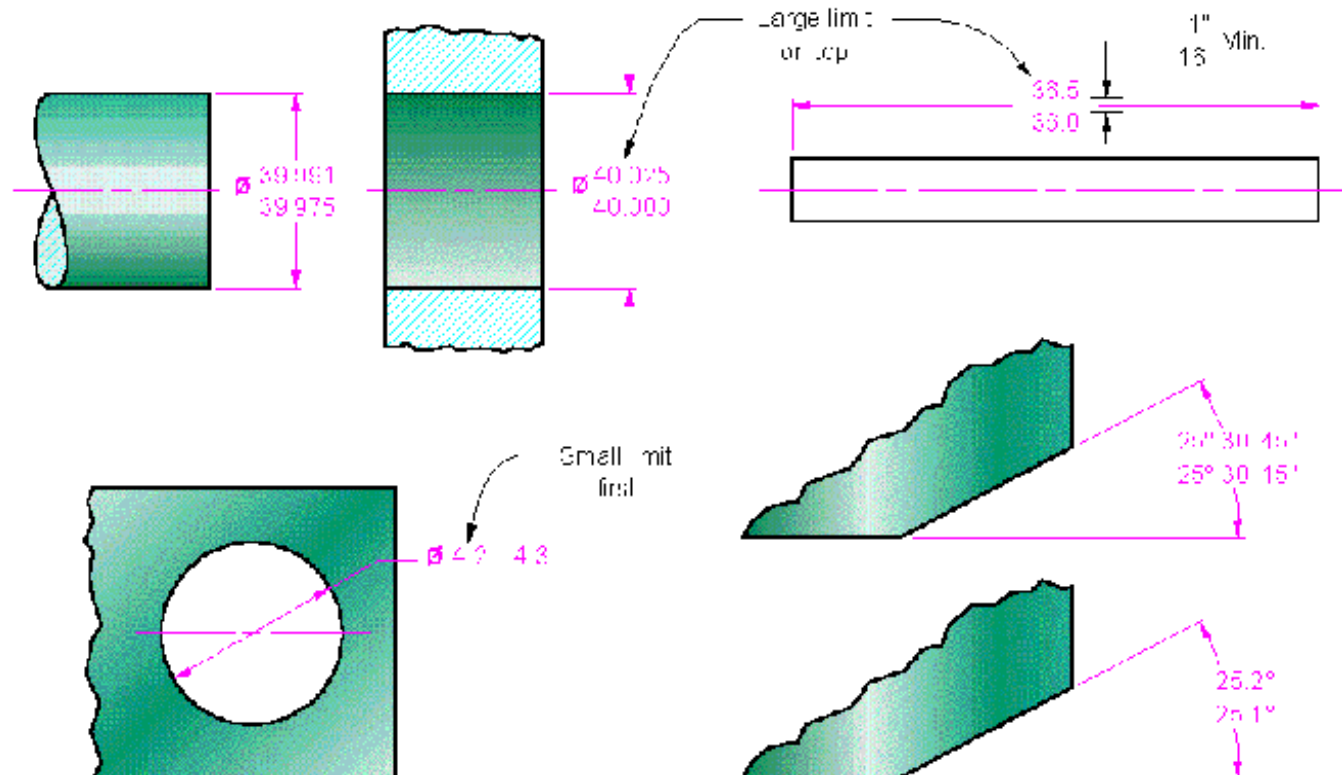
Tightest fit =
40.000 - 39.991 =
.009



Method 2
Note Form

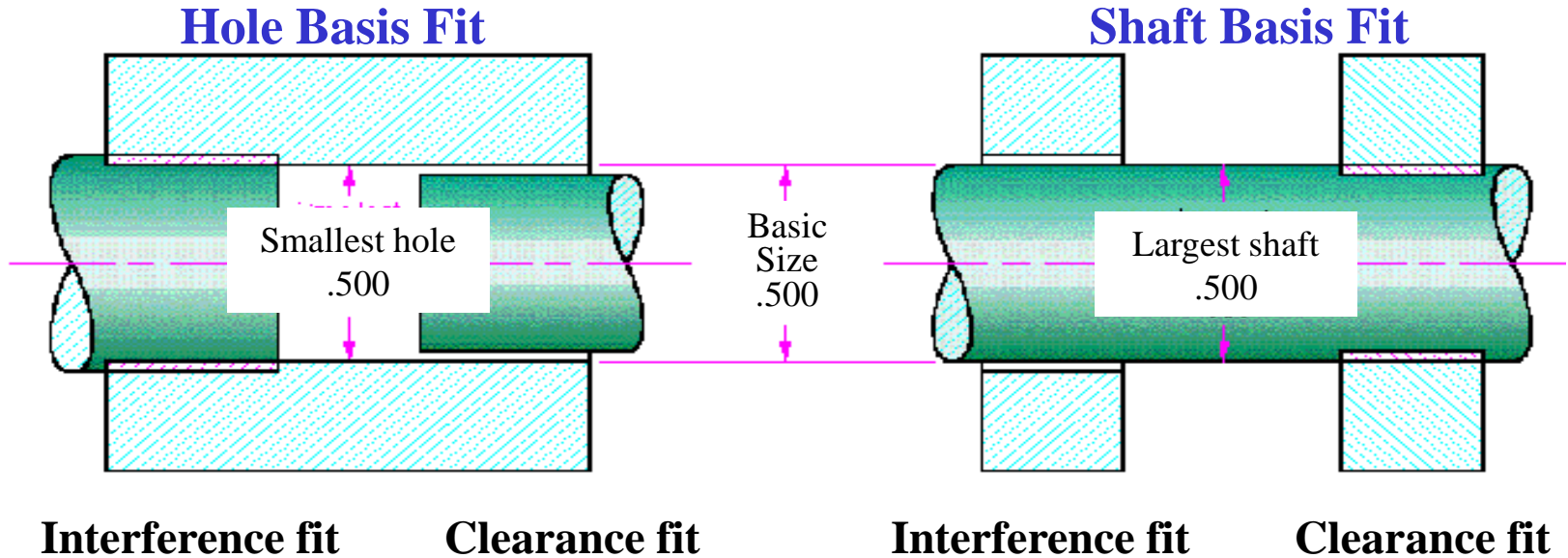
<table border="1"> <tr><th>Hole</th></tr> <tr><td>40.025</td></tr> <tr><td>40.000</td></tr> <tr><td><hr style="width: 50%; margin: 0;"/></td></tr> <tr><td>.025</td></tr> </table> <p>Tightest fit</p>	Hole	40.025	40.000	<hr style="width: 50%; margin: 0;"/>	.025	<table border="1"> <tr><th>Shaft</th></tr> <tr><td>39.991</td></tr> <tr><td>39.975</td></tr> <tr><td><hr style="width: 50%; margin: 0;"/></td></tr> <tr><td>.016</td></tr> </table> <p>Loosest fit</p>	Shaft	39.991	39.975	<hr style="width: 50%; margin: 0;"/>	.016
Hole											
40.025											
40.000											
<hr style="width: 50%; margin: 0;"/>											
.025											
Shaft											
39.991											
39.975											
<hr style="width: 50%; margin: 0;"/>											
.016											

Metric Tolerances-Standard representation



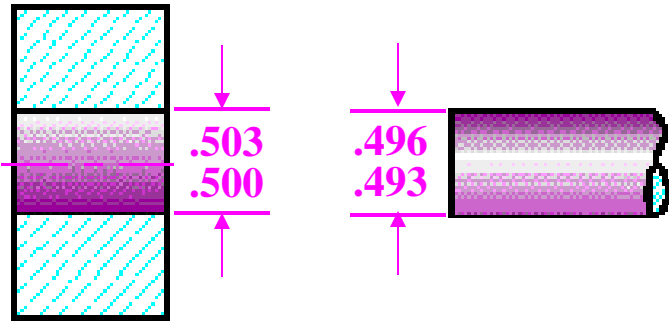
- If limits are shown up and down, largest limit up
- If shown side by side, smallest limit first
- For angular dimensions, it can be in general note or it can be mentioned similar to that of linear dimensions

Basic hole and shaft system-Imperial size



- **Hole Basis fit:** the basic size is the minimum dia of the hole and fit is calculated based on this
- **Shaft Basis fit:** the basic size is the maximum dia of the shaft and the fit is calculated base on this

Example – Run Fit



0.500 is the lower limit hole
0.496 is the upper limit shaft
0.004 is the ALLOWANCE

0.496 is the upper limit shaft
0.003 is the shaft tolerance
0.493 is the LOWER LIMIT SHAFT

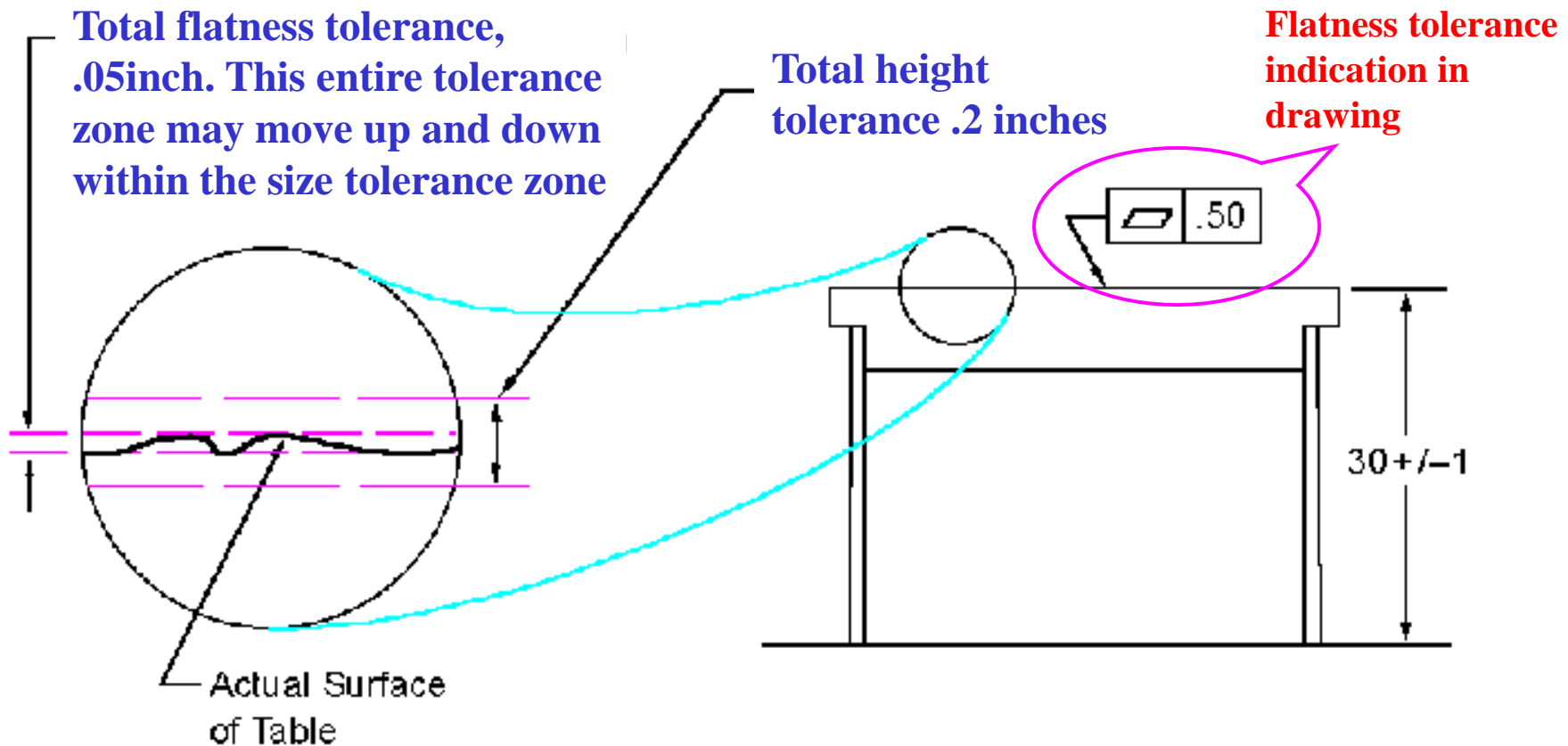
0.500 is the lower limit hole
0.003 is the hole tolerance
0.503 is the UPPER LIMIT HOLE

0.500 is the smallest hole
0.496 is the largest shaft
0.004 is the tightest fit

0.503 is the largest hole
0.493 is the smallest shaft
0.10 is the loosest fit

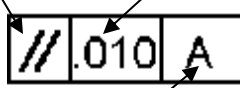
Geometric tolerancing

- Used to limit the abatement in the geometric or positional variation of features

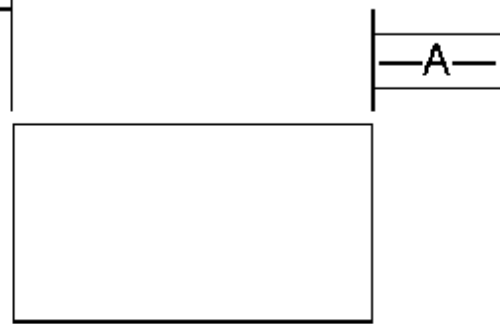


Example of feature control frames

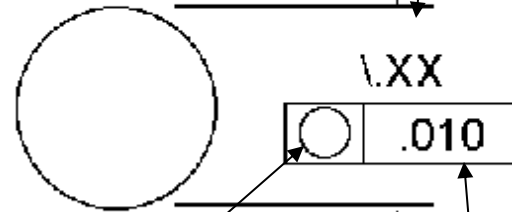
Geometric tolerance symbol (Parallelism) Geometric tolerance value



Reference Datum



Size dimension



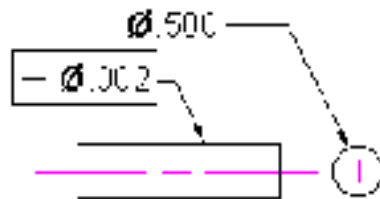
Geometric tolerance symbol (Roundness)

Geometric tolerance value

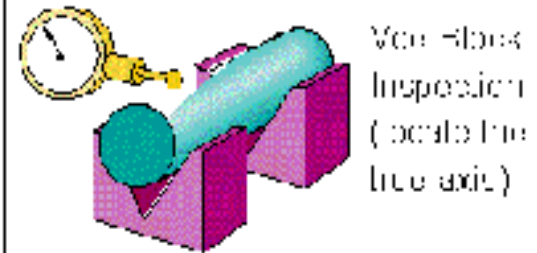
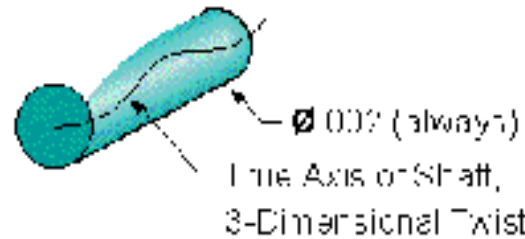
Dimensioning and tolerancing symbols

General Tolerance Symbols	Tolerance Symbols of Form, Orientation, and Location																																				
<p>Material Condition</p> <p>(M) Maximum Material Condition</p> <p>(L) Least Material Condition</p> <p>(S) Regardless of Feature Size</p> <p>-A- Primary Datum</p> <p>-B- Secondary Datum</p> <p>-C- Tertiary Datum</p>	<table border="1"> <thead> <tr> <th>Symbol</th> <th>Characteristic</th> <th>Type of Tolerance</th> </tr> </thead> <tbody> <tr> <td></td> <td>Flatness</td> <td rowspan="4">Form</td> </tr> <tr> <td></td> <td>Straightness</td> </tr> <tr> <td></td> <td>Roundness</td> </tr> <tr> <td></td> <td>Cylindricity</td> </tr> <tr> <td></td> <td>Profile of a Line</td> <td rowspan="2">Profile</td> </tr> <tr> <td></td> <td>Profile of a Surface</td> </tr> <tr> <td></td> <td>Angularity</td> <td rowspan="3">Orientation</td> </tr> <tr> <td></td> <td>Perpendicularity</td> </tr> <tr> <td></td> <td>Parallelism</td> </tr> <tr> <td></td> <td>Position</td> <td rowspan="3">Location</td> </tr> <tr> <td></td> <td>Concentricity</td> </tr> <tr> <td></td> <td>Symmetry</td> </tr> <tr> <td></td> <td>Circular Runout</td> <td rowspan="2">Runout</td> </tr> <tr> <td></td> <td>Total Runout</td> </tr> </tbody> </table>	Symbol	Characteristic	Type of Tolerance		Flatness	Form		Straightness		Roundness		Cylindricity		Profile of a Line	Profile		Profile of a Surface		Angularity	Orientation		Perpendicularity		Parallelism		Position	Location		Concentricity		Symmetry		Circular Runout	Runout		Total Runout
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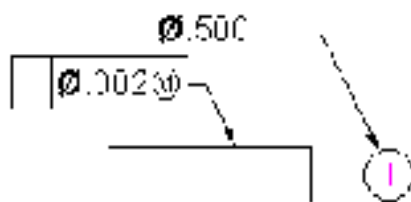
Straightness of the axis



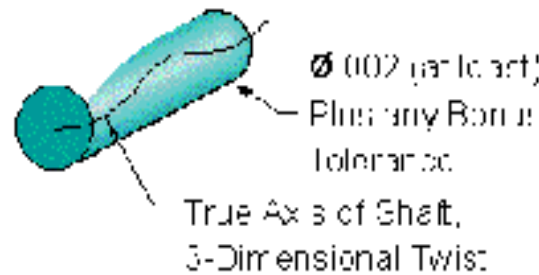
±FS Basis



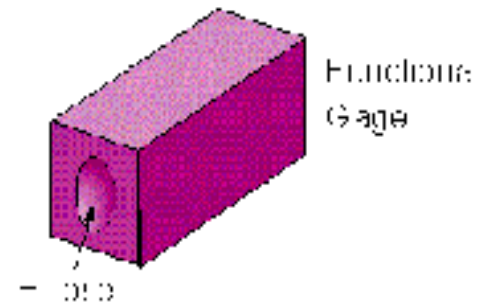
MVC Modified



Drawing

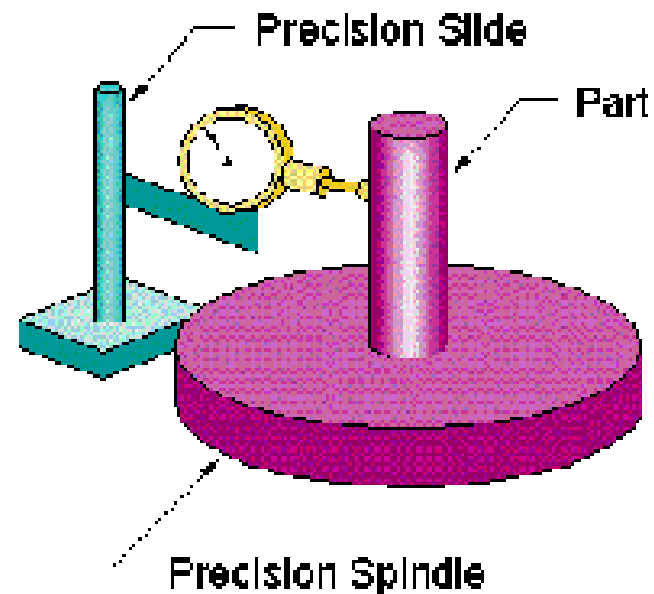
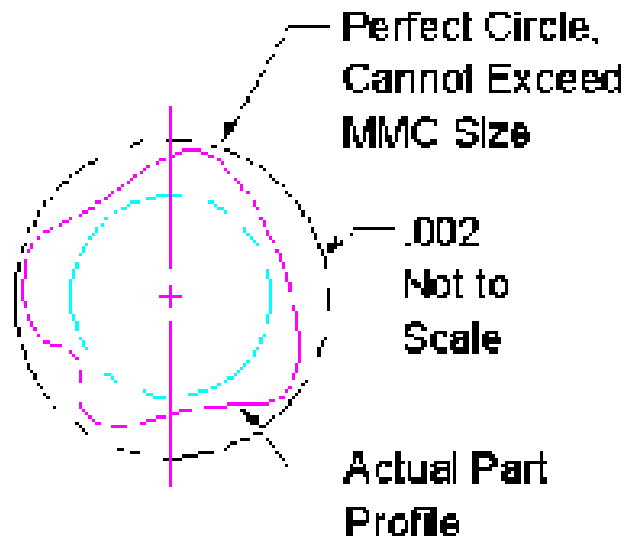
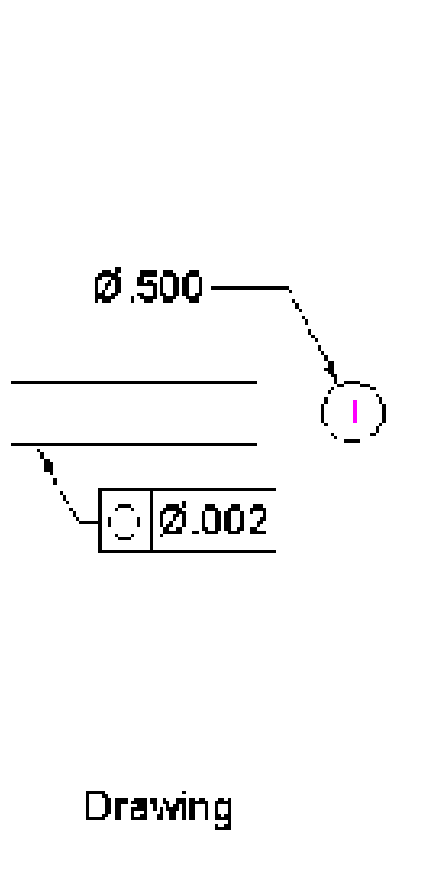


Effect
(scale enlarged)

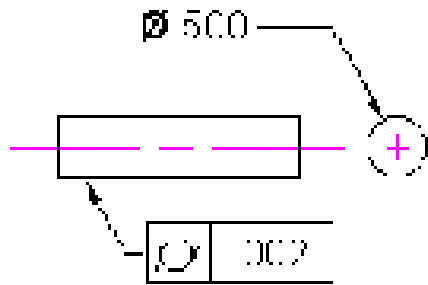


Inspection Methods

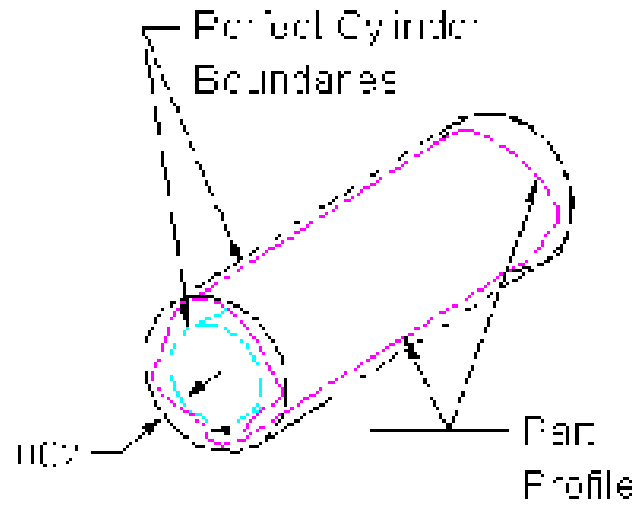
Roundness



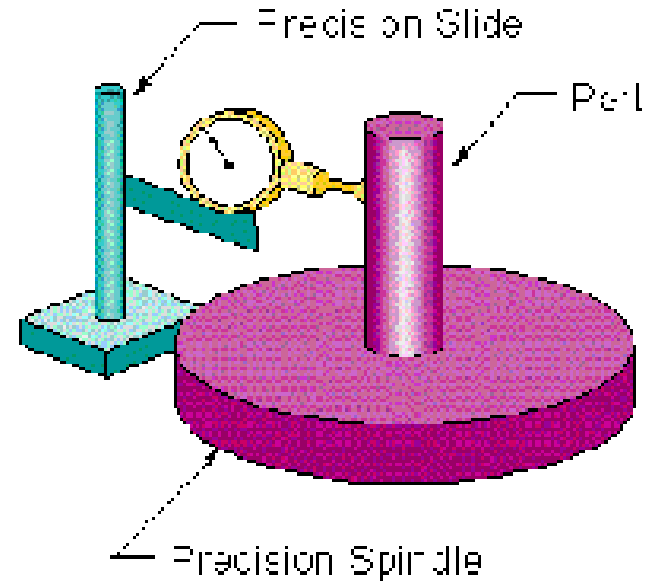
Cylindricity



Dimensioning

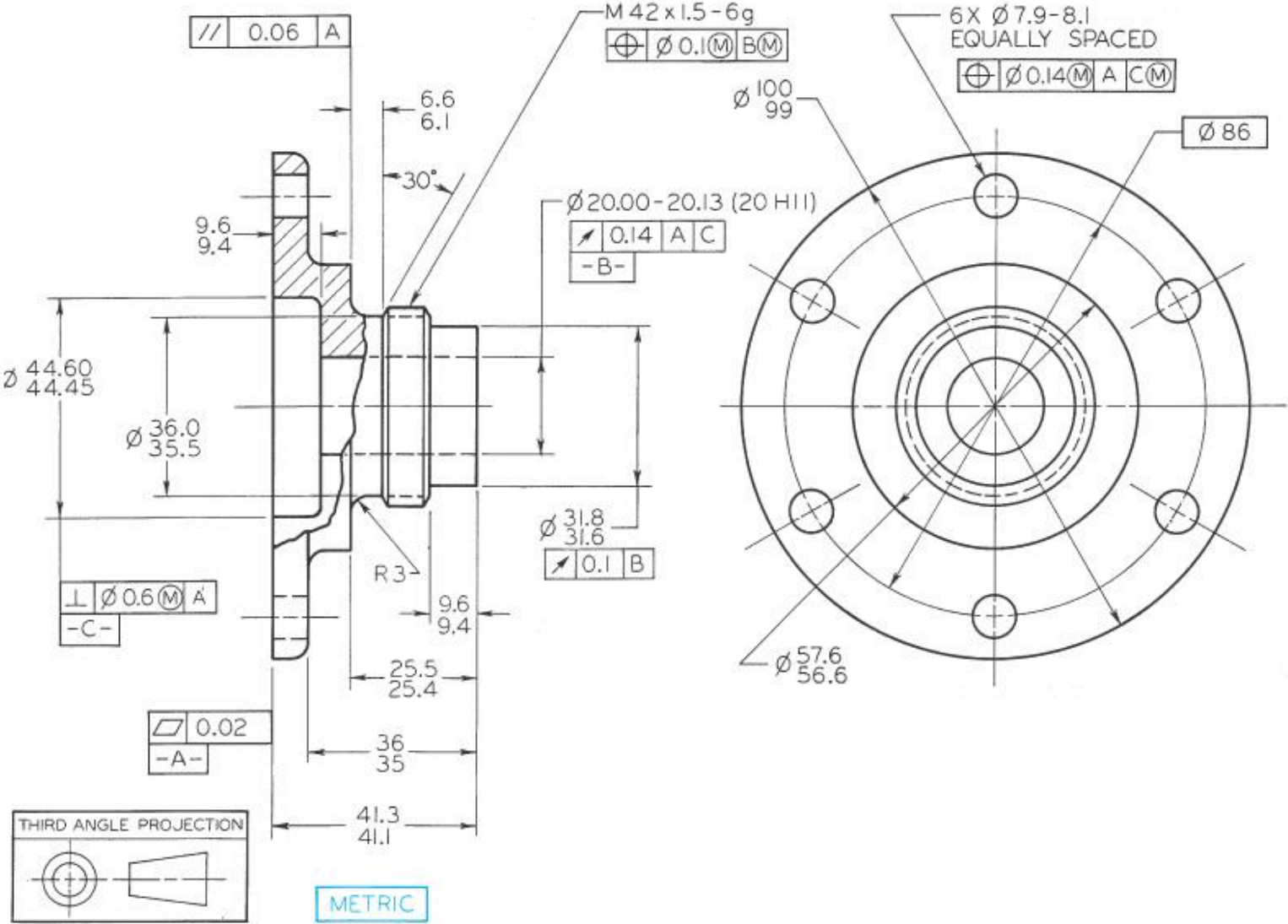


Fit/real



Inspection Method

Drawing with GT - Example





Machine elements

Fasteners, gears, bearings, welding

MECHANICAL ENGINEERING

DRAWING

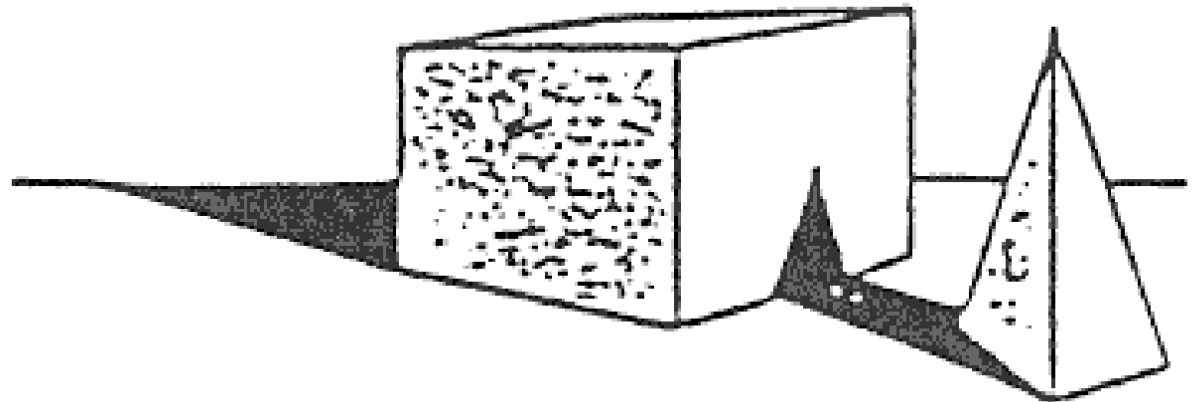
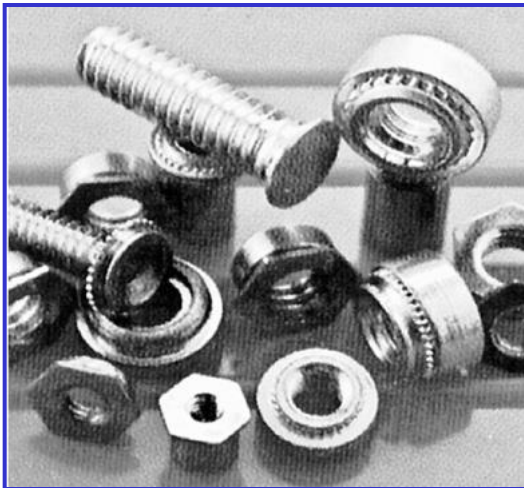
MECH 211

Content of the lecture

- Machine elements and standards
- Non-permanent fasteners – bolts and screws
 - Features, representation, assembly representation and note
- Other non-permanent fasteners
- Permanent fasteners – rivets, joining through soldering, brazing and welding
- Springs
- Assembly drawings
- Machine elements: gears, cams, bearings, etc.
- Examples of mechanisms and representations

Fasteners

- Use to join two or more components
- Two major categories:
 - Non-permanent fastening methods
 - Permanent fastening methods
- The Boeing 747 has 2.5 million **fasteners!**



Non-permanent fasteners

- Bolts and nuts, machine screws, studs, pins, rings, keys, etc.
- An assembly could be disassembled without destroying the fastener or a part of the assembly

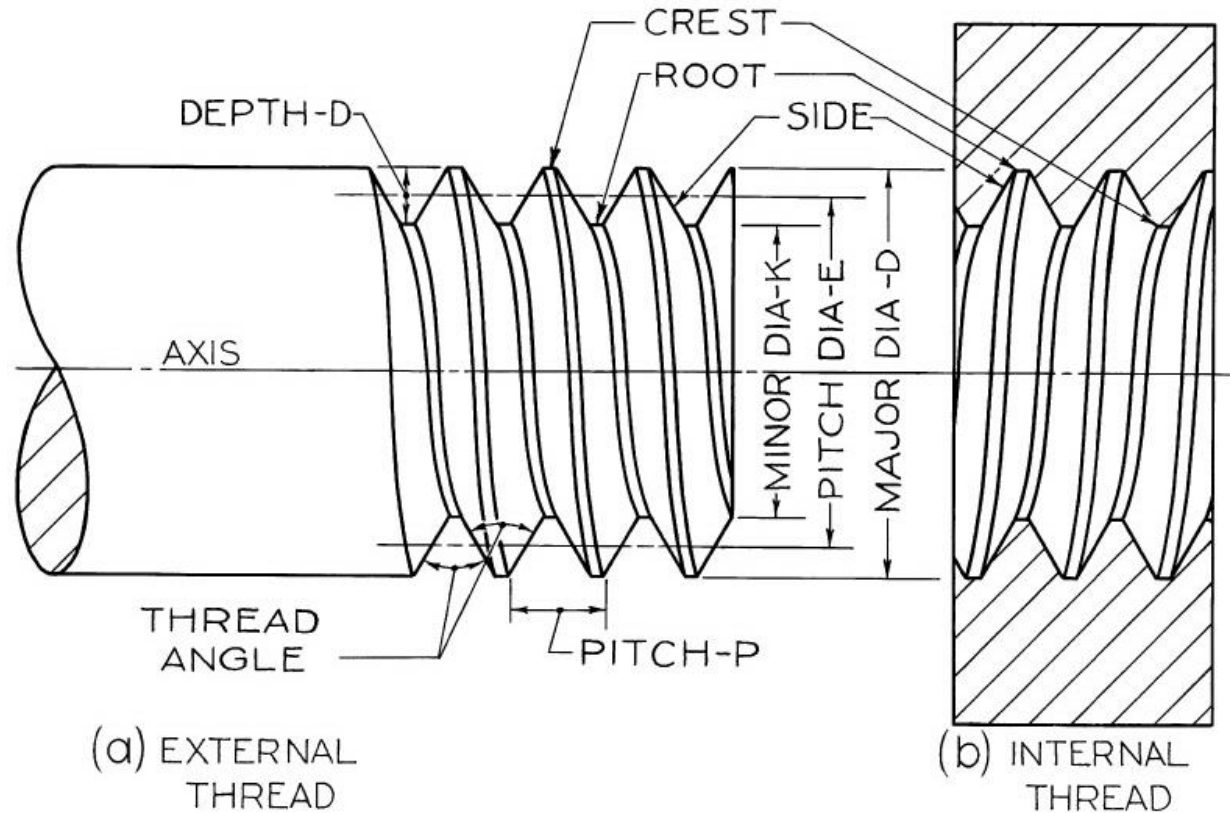


Bolts, nuts and machine screws

- Used to assemble machine parts through the friction obtained in a helical groove made on two conjugated parts
- The threads are cut or rolled in a blank of material (metal) while the conjugate part moves axially on the thread when turned
- Bolts and nuts must have the same geometric features in order to be mated.

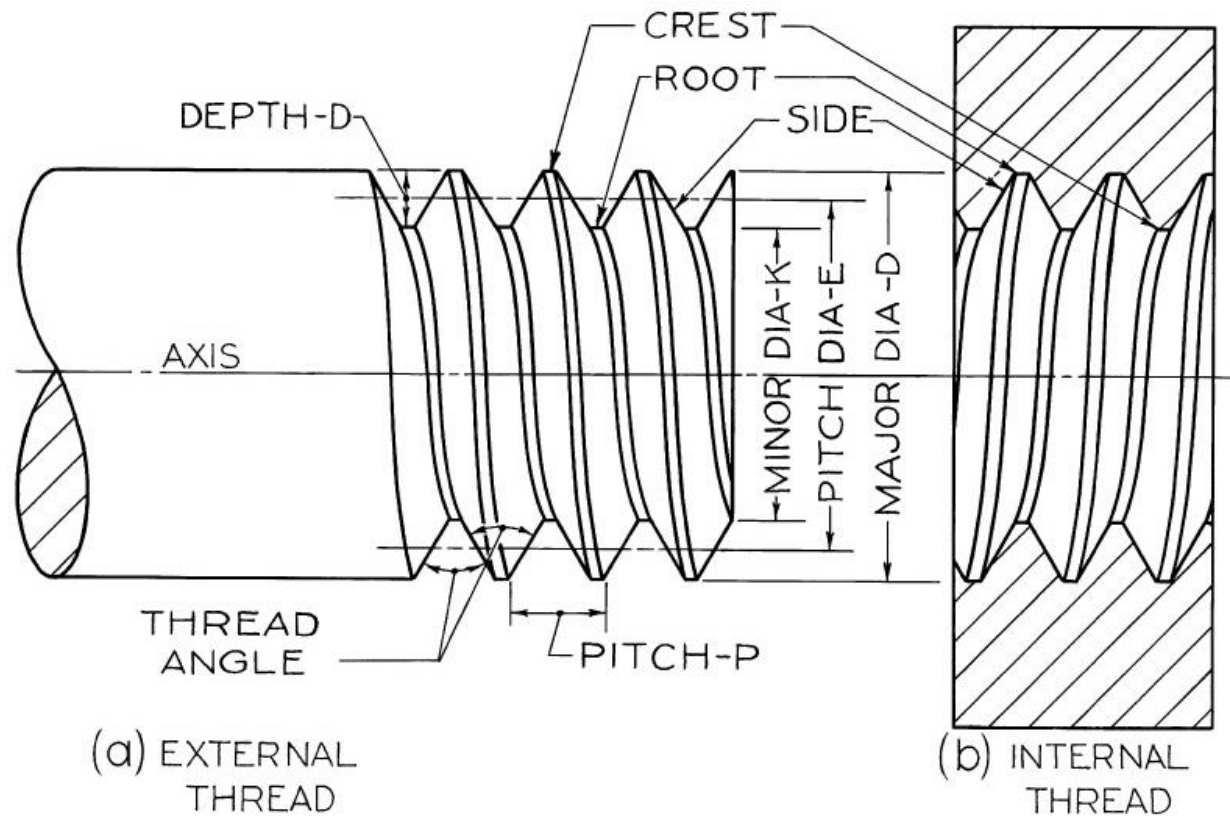
Screw and thread terminology

- **Screw Thread** - A ridge of uniform section in the form of a helix on the external or internal surface of a cylinder.
- **Major Diameter** - The largest diameter of a screw thread.
- **Minor Diameter** - The smallest diameter of a screw thread.



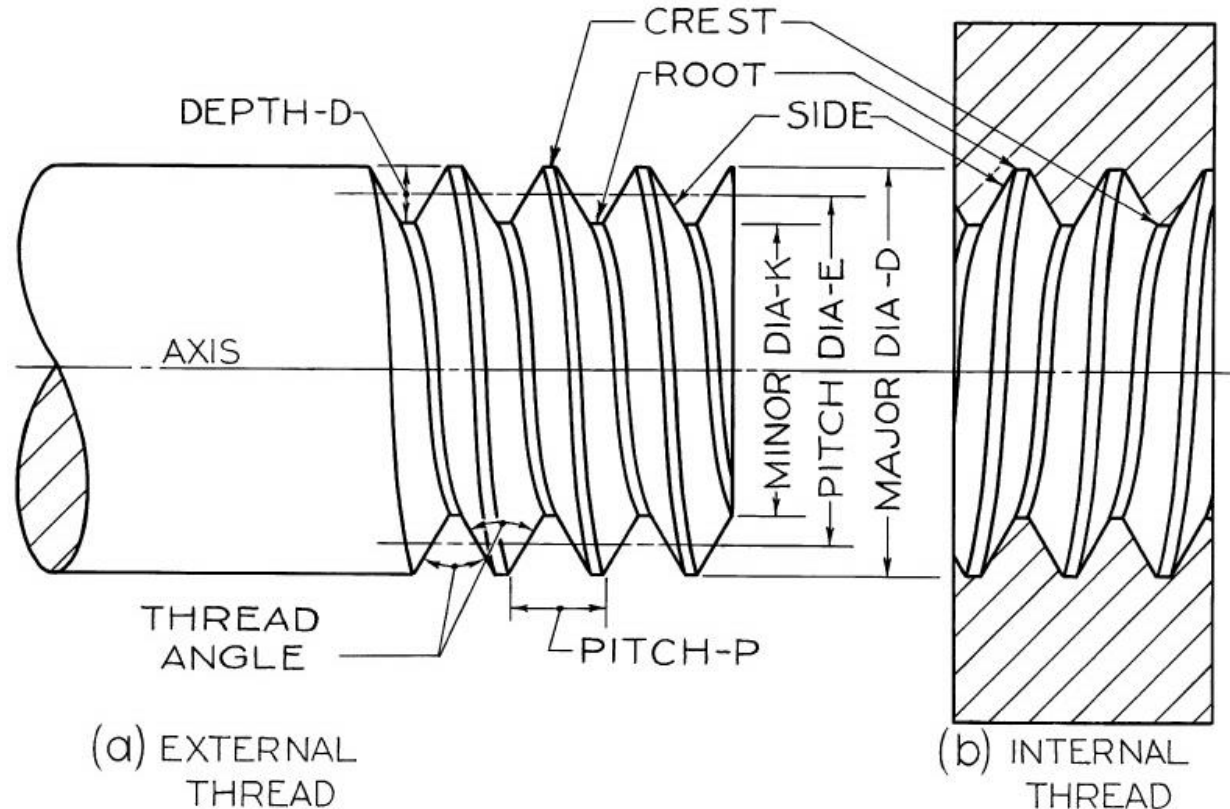
Screw and thread terminology

- **Axis** – the longitudinal center line of the original work (blank) or hole
- **Chamfer** – the angular relief at the beginning or end of the thread to allow easier engagement with the mating part
- **Crest** – the peak of the top of a thread
- **Depth** – the distance between the crest and the root



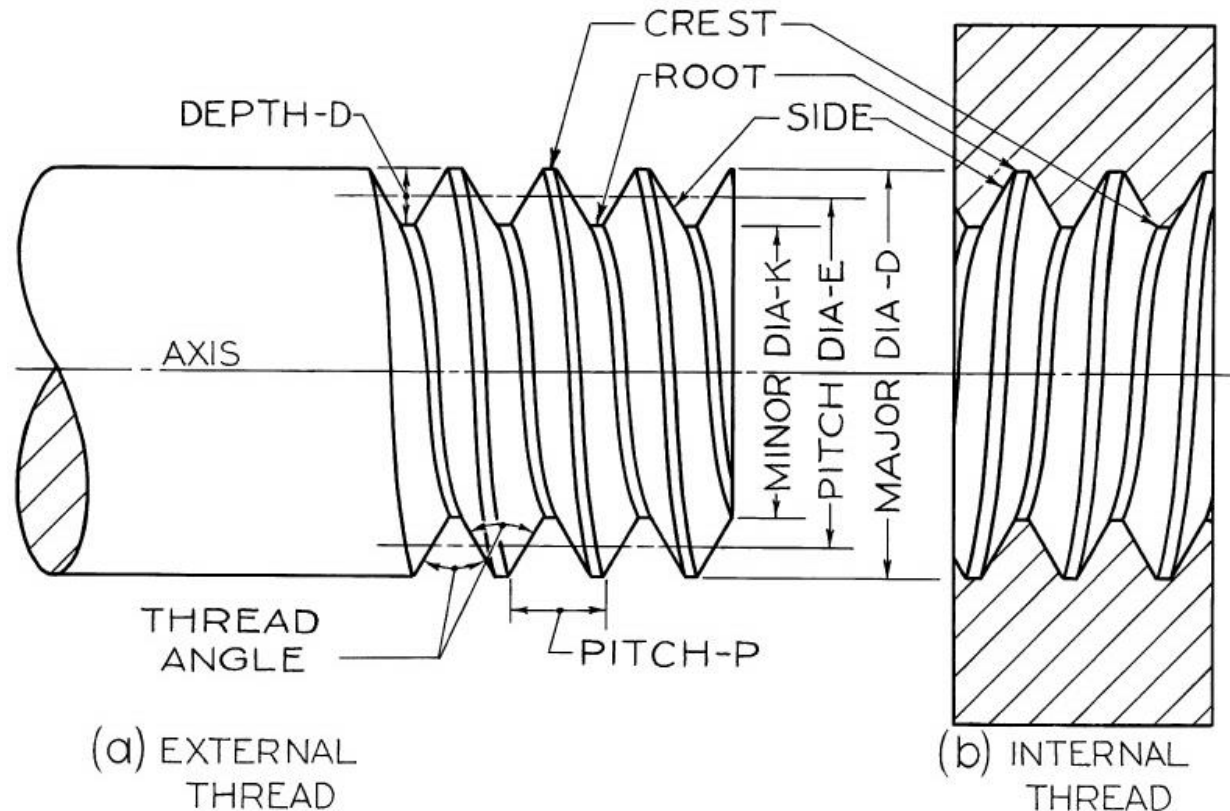
Screw and thread terminology

- **Die** – the tool used to perform external threads
- **External thread** – the screw thread on the outside of a cylindrical surface
- **Internal thread** – the screw thread on the inside of a cylindrical surface
- **Lead** – the distance that a screw will travel along the axis when turned by 360°



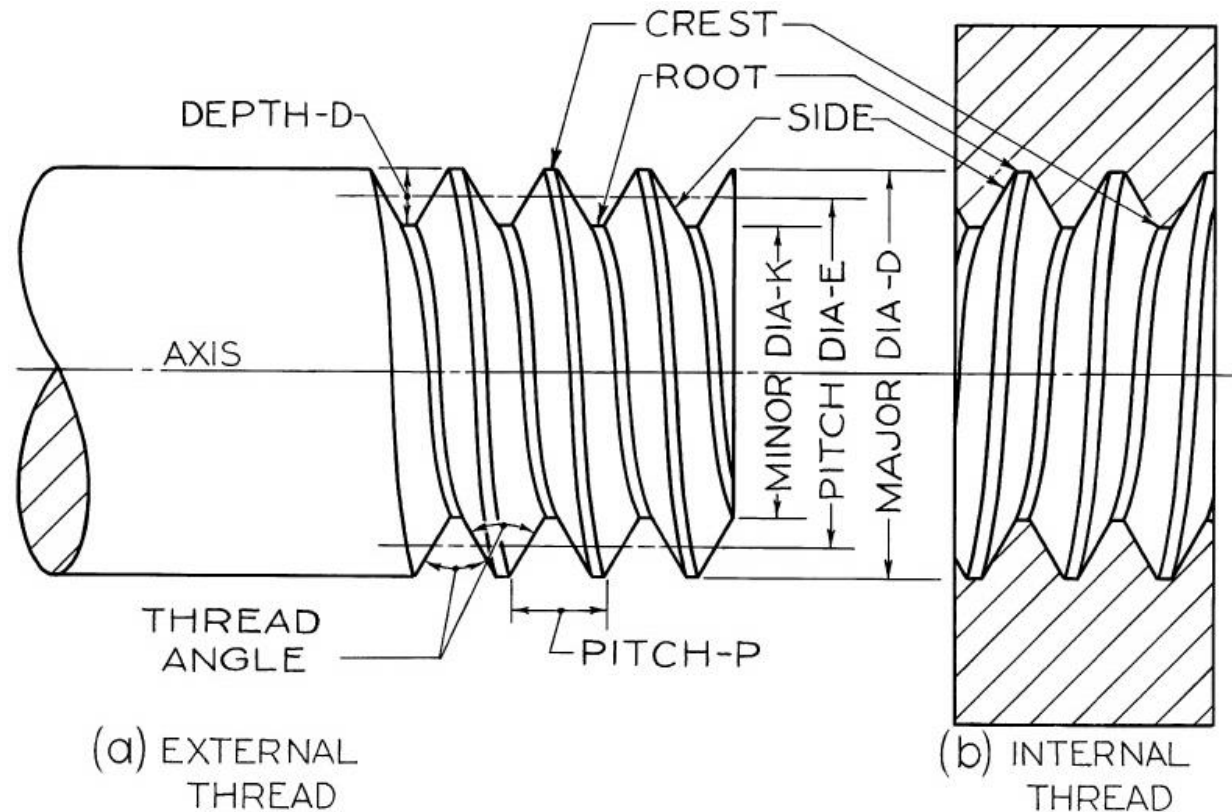
Screw and thread terminology

- **Pitch** – the distance between corresponding points on adjacent thread forms, measured parallel to the axis expressed in 1 divided by the number of pitch in one inch
- **Pitch diameter** – the diameter of an imaginary cylinder that is located equidistant between the major and the minor diameter



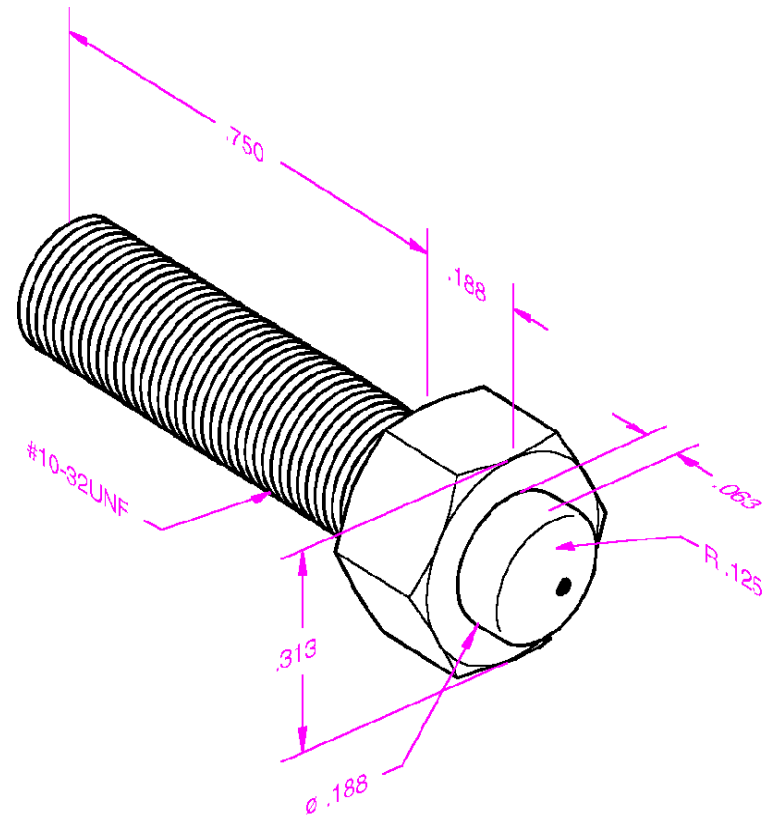
Screw and thread terminology

- **Root** – the bottom of the screw thread cut in a cylinder
- **Tap** – the tool used to thread holes
- **Thread angle** – the angle between the surfaces of two adjacent threads
- **Thread series** – the number of threads per inch for a given diameter

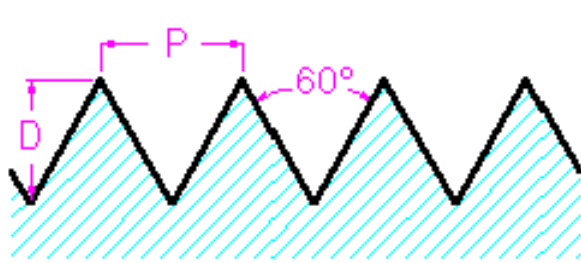


Thread specifications – imperial system

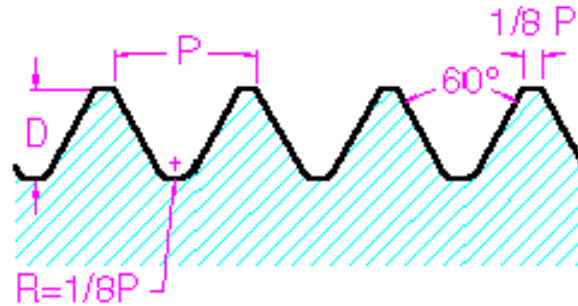
- ANSI Y14.6 - 1998
- Thread form
- Thread series
- Major diameter
- Class of fit
- Threads per inch



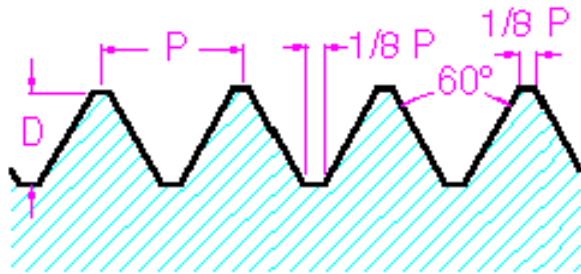
Form



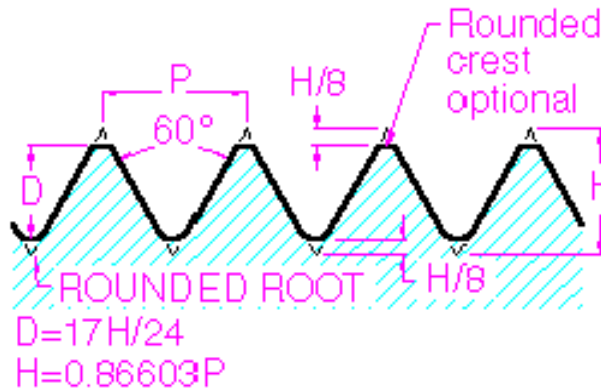
(A) Sharp V



(B) Unified National Round



(C) American National

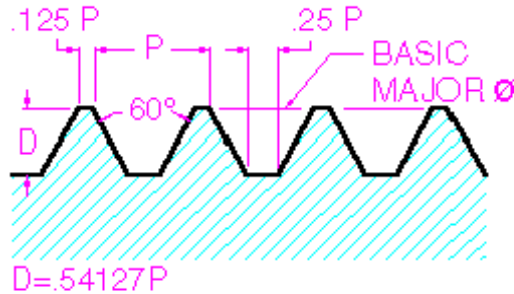


(D) Unified (external)

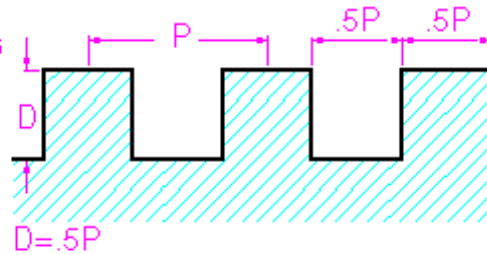
- Shows some common thread forms
- Inch & Metric have same proportion
- **Sharp V** was original american national thread
- **American national** now has flattened root and crest to increase strength

- **Unified thread** is agreed as standard in US, Canada and Britain, the crest may be flat or rounded but the root is rounded. Otherwise similar to American national

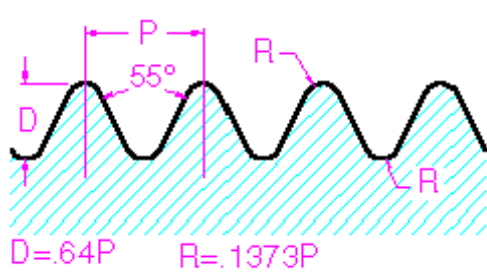
Form



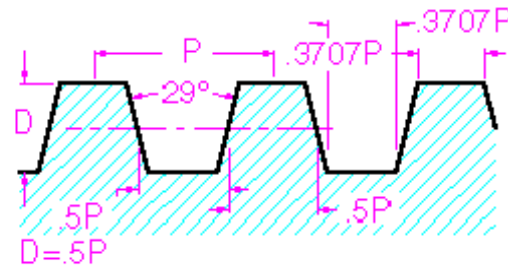
(E) Metric



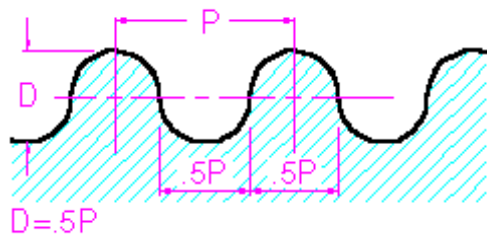
(F) Square



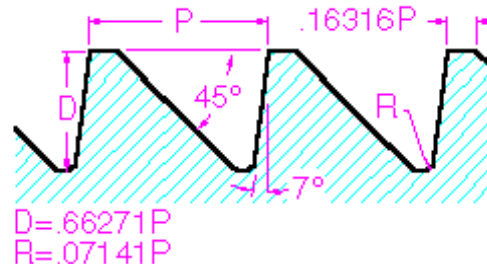
(G) Whitworth Standard



(H) Acme



(I) Knuckle

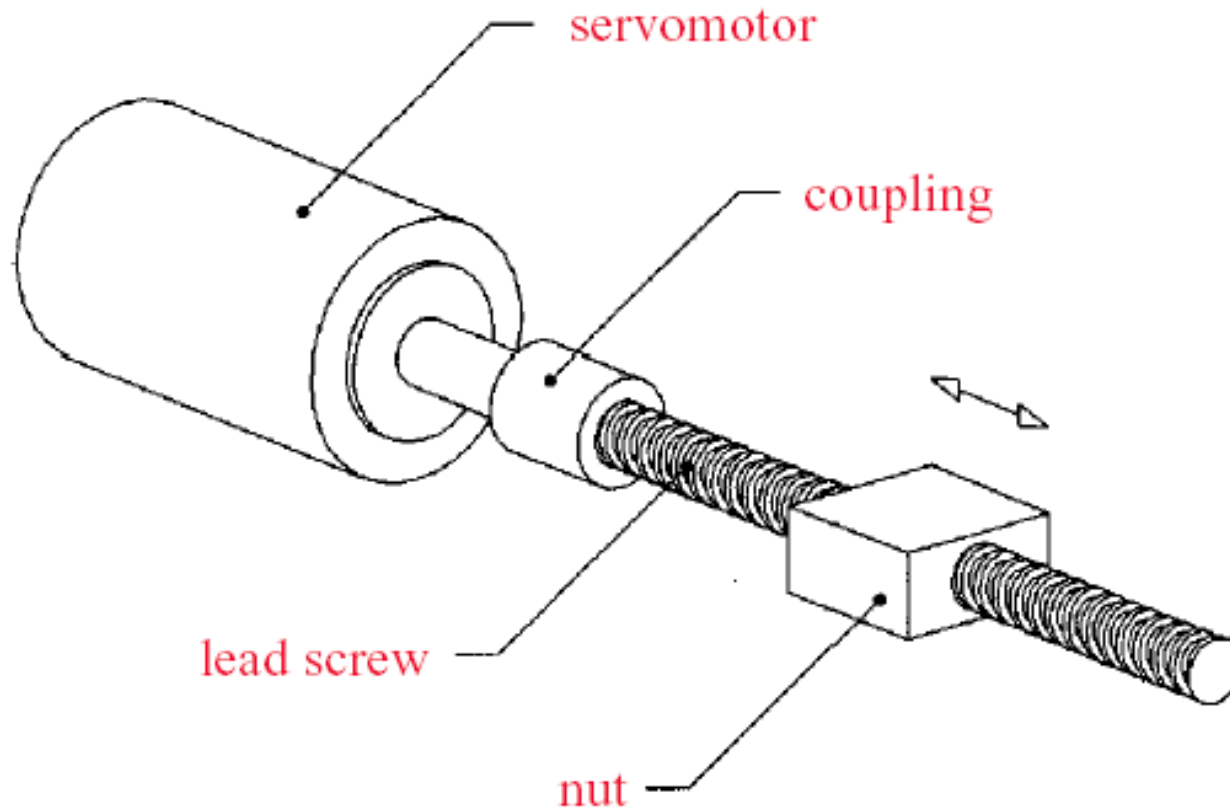


(J) Buttress

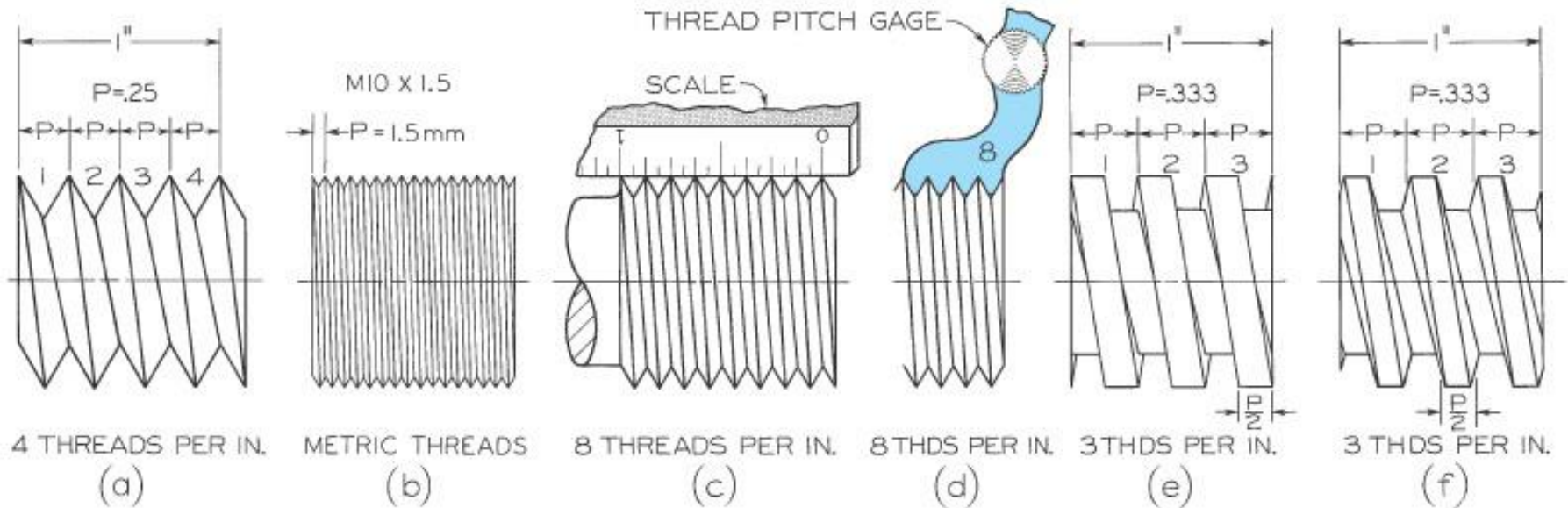
- **ISO Metric** is the most common of all the depth is smaller than that of unified national thread
- **Knuckle thread** is rolled or cast (used in light bulbs and sockets)
- **Square and Acme** threads are used for transmitting power
- **Buttress thread** takes pressure on one side (\perp to the axis)

Motion and measurement screws

Controls and positioning applications



Measuring thread pitch



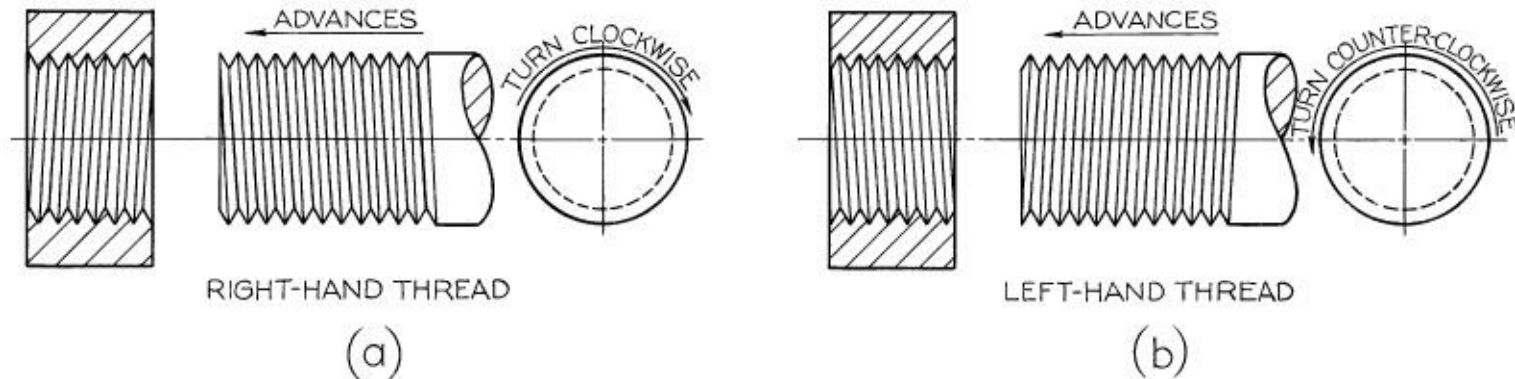
- **Pitch** is the distance parallel to axis between corresponding points in adjacent thread
- **Pitch** is measured in millimeters for metric thread and indicated along with the major dia (eg. M10 X 1.5)
- For inch threads, it is mentioned as threads per inch
- **Thread Pitch** is measured with scale or a **thread pitch gage**

Series

- **Series** depends on the pitch and the major dia of the thread
- **Coarse series** – used for quick assembly and disassembly of cast iron, soft metals and plastics (**UNC**) – Less TPI
- **Fine series** – used when a great deal of force is necessary for assembly (**UNF**) - More TPI
- **Extra fine series** – used when the length of engagement is short and the application calls for high degrees of stress (**UNEF**) – Lot of TPI

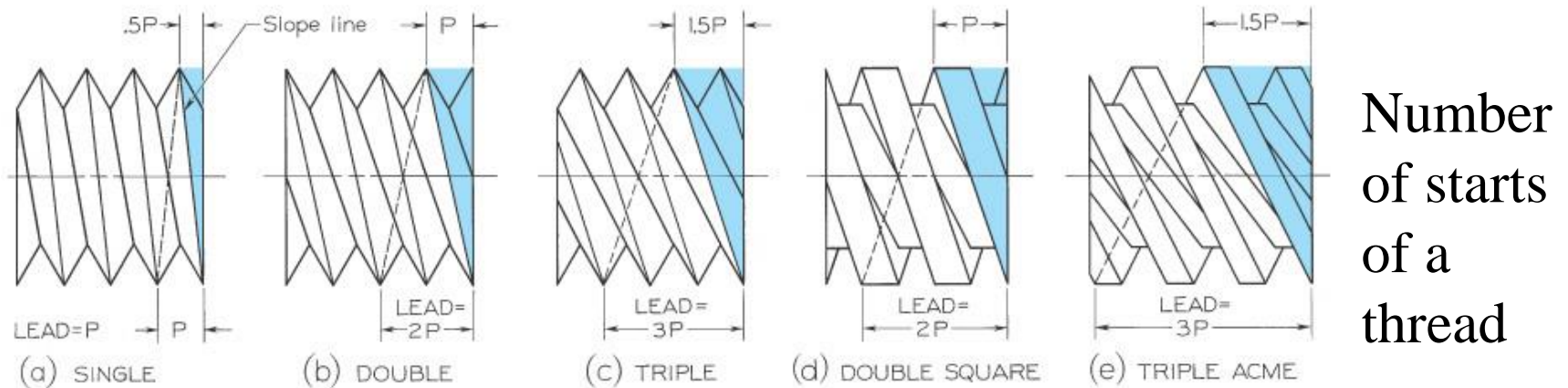
Series

- If it is not stated in the drawing, it is always assumed to be right hand thread
- A bolt threaded into a tapered hole should be turned clockwise



- Some special cases (where the torque may loosen the fastener) may require Left hand threads
- If Left hand threads are necessary it is indicated in the drawing by the letters LH after the thread designation

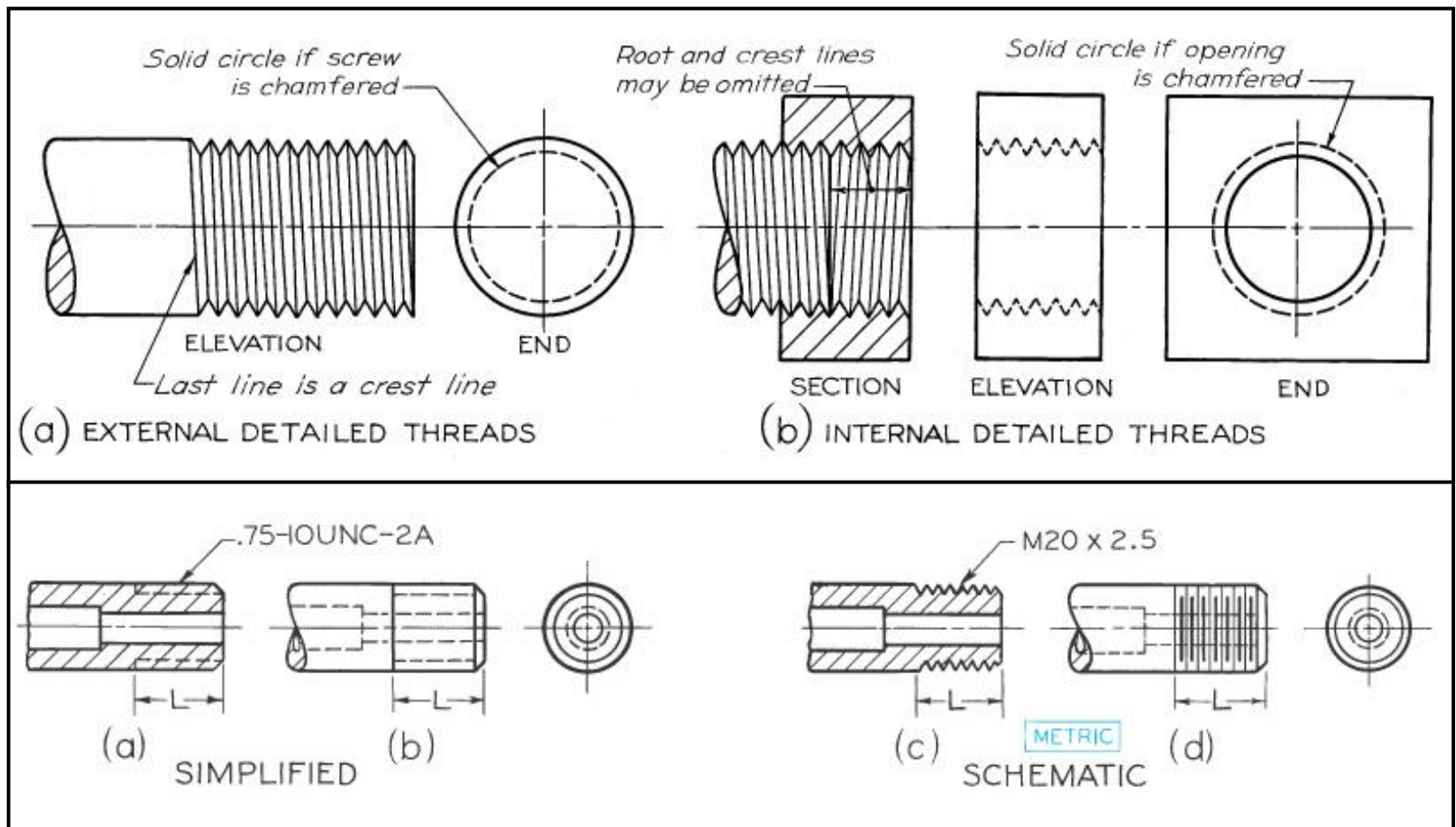
Single and multiple thread forms



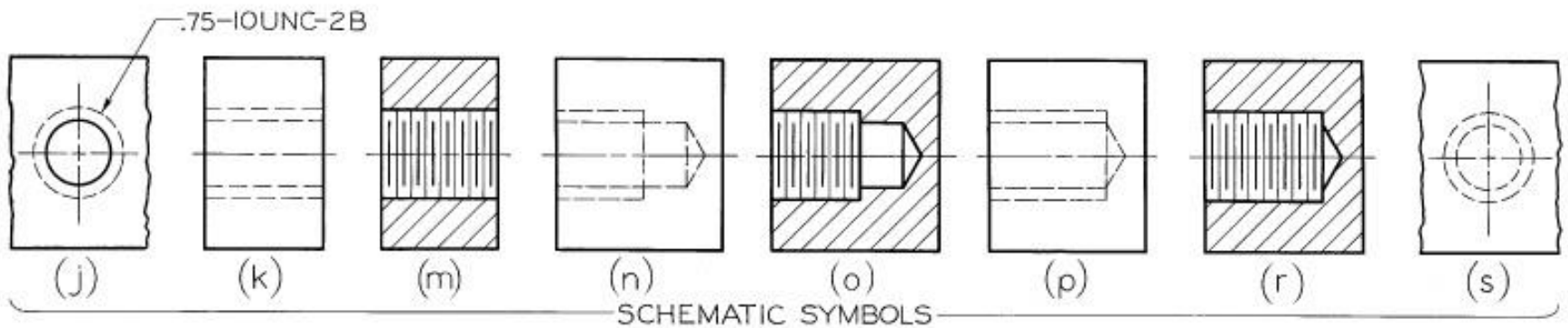
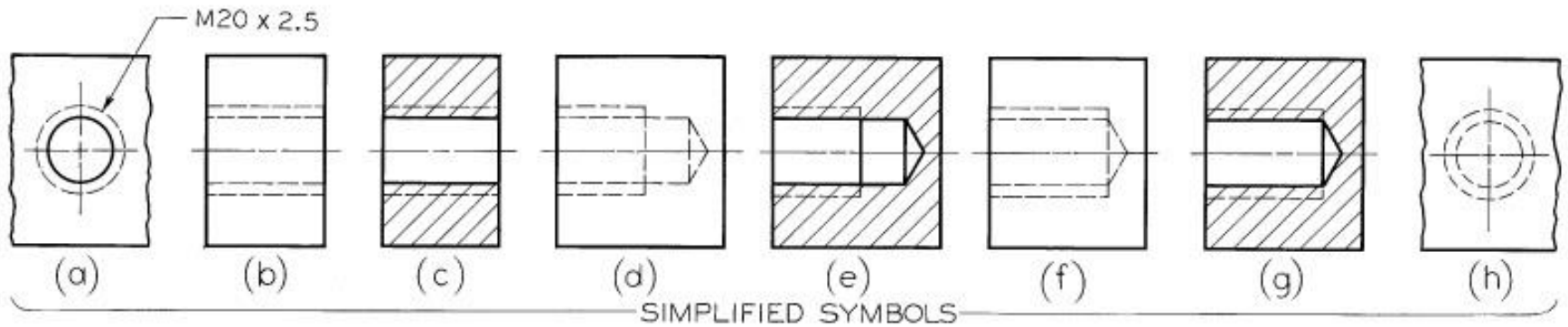
- If it is not stated in the drawing, it is always assumed to be single thread
- Single thread has a single ridge in the form of helix and lead = pitch
- Multiple threads have 2 or more ridges running side by side
- The slope line is the hypotenuse of the right triangle whose short side = $.5P$ for single thread and p for double and $1.5 P$ for triple threads
- Multiple threads are required when small rotation must give faster movement at low required power (Eg. Toothpaste caps)

Thread Symbols

- Can use, simple, schematic or detailed as needed. Simplified is common
- Detailed is more pleasing, so for major dias $>1''$ detailed is preferred



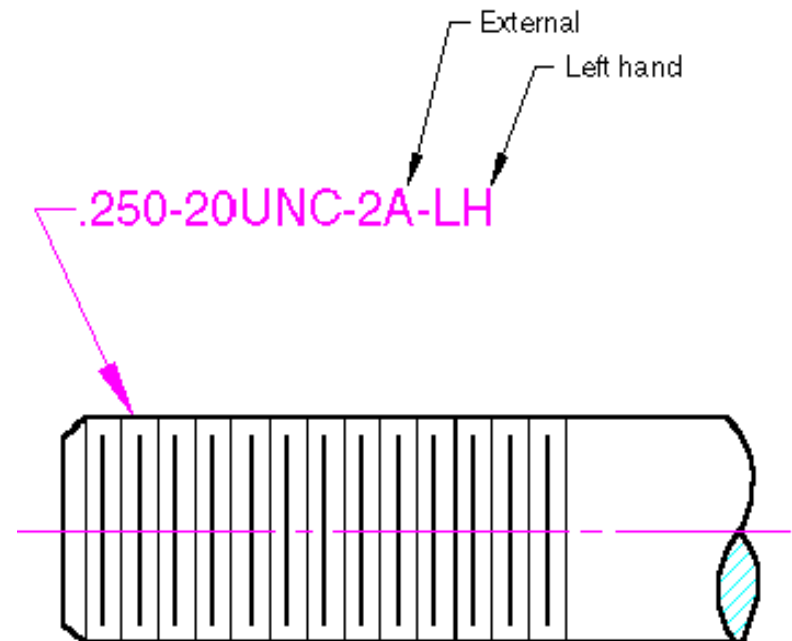
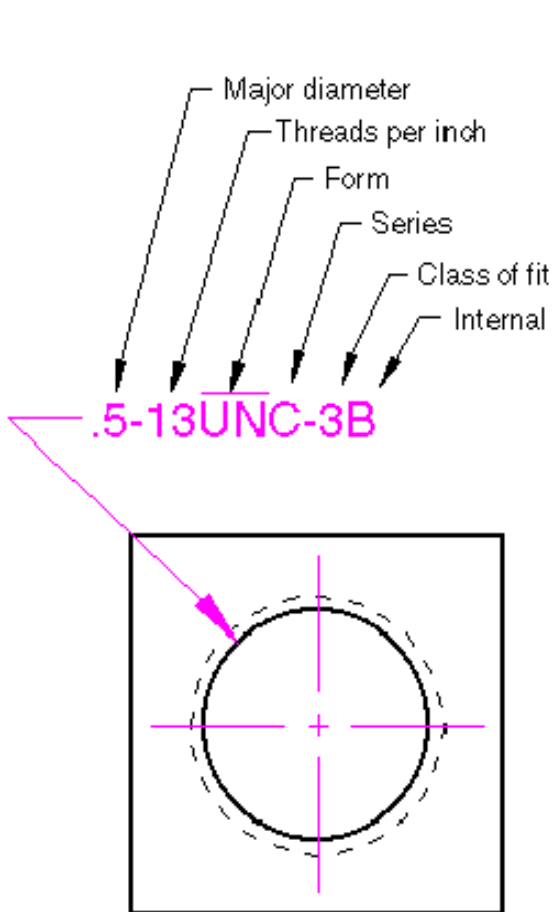
Thread Symbols



Class of fit

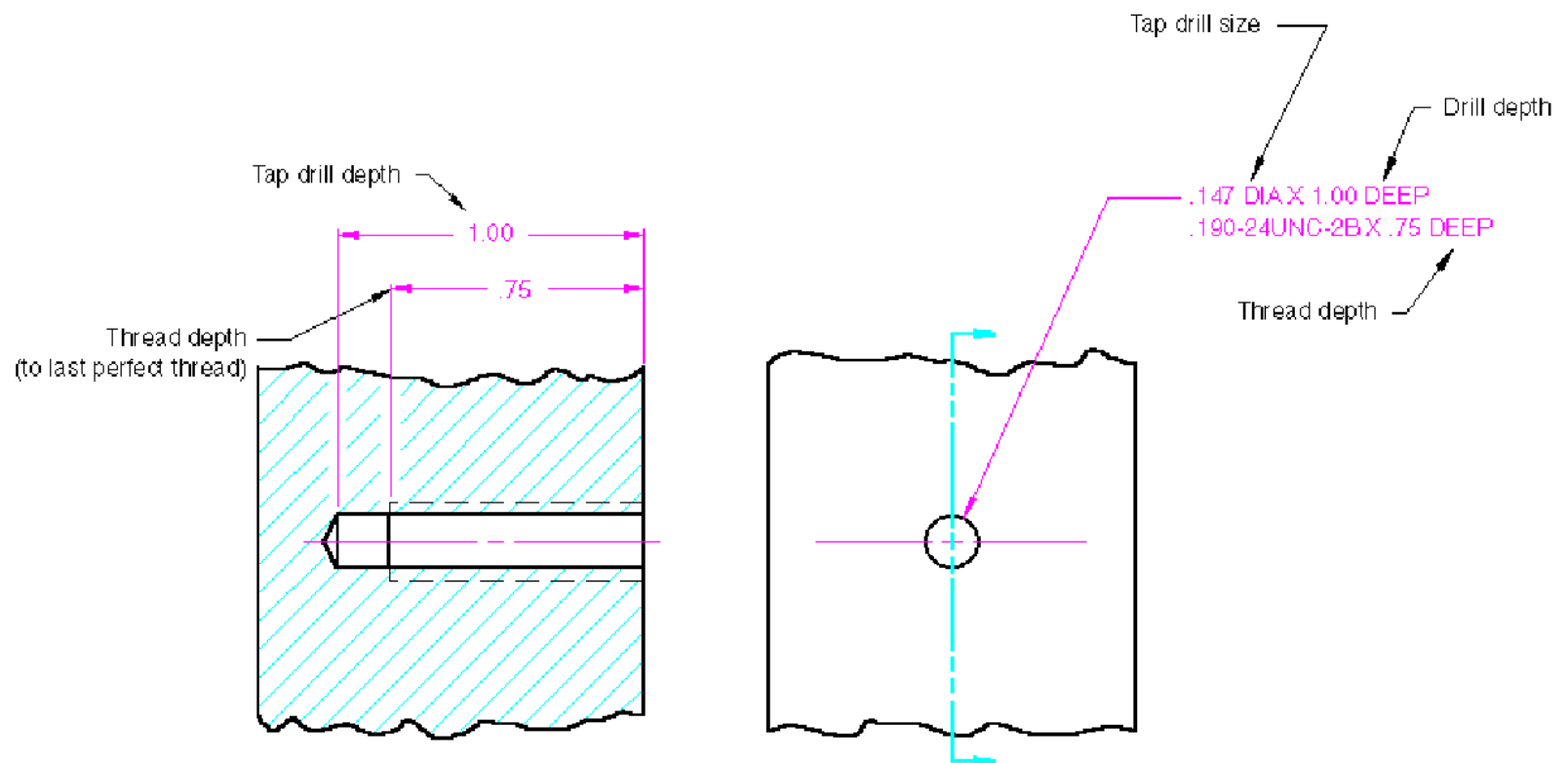
- **Class 1 A and B** – a loose fit where quick assembly is required and play between parts is acceptable
- **Class 2 A and B** – a high quality general purpose commercial class of fit for bolts, nuts and screws used in mass production
- **Class 3 A and B** – a very high quality threaded fasteners with a close fit used for precision assembly subjected to vibrations
- **A** is for external threads and **B** is for internal threads

Thread notes



UNC	Means Unified National Coarse
UNF	Means Unified National Fine
UNEF	Means Unified Extra Fine Series
UN	Means Uniform Pitch Series
UNM	Means Unified Miniature Series
NC	Means National Coarse Series
NF	Means National Fine Series
UNR	Means Unified National Round

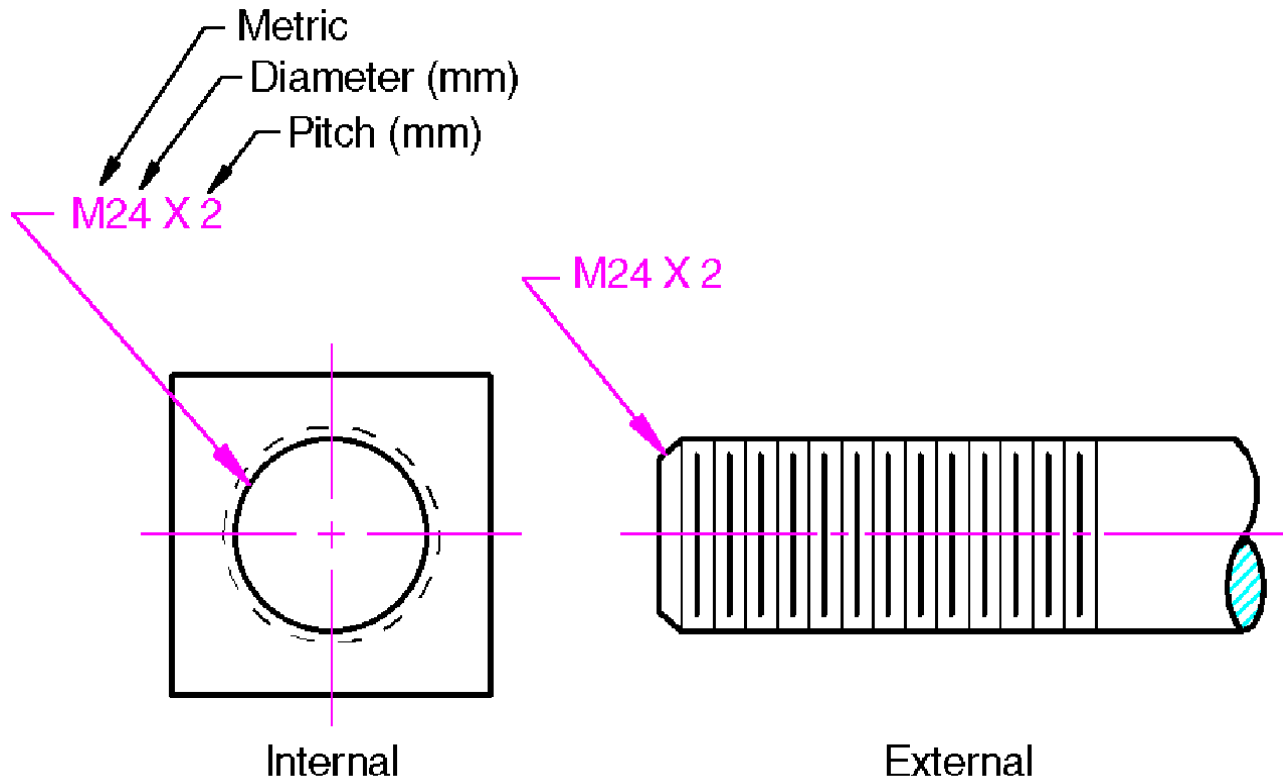
How to represent a thread



ISO representation of threads

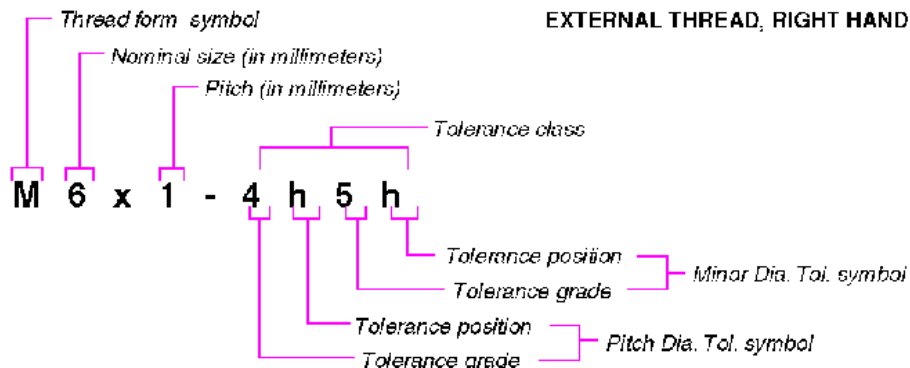
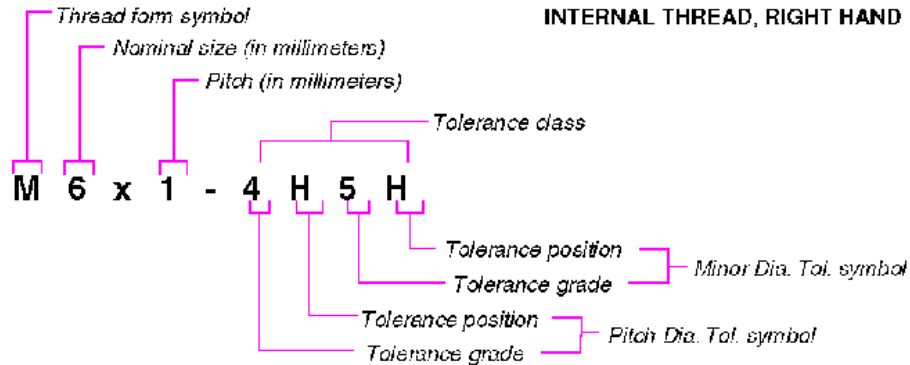
- Thread form symbol – **M**
- Nominal size – **in mm**
- Pitch size – **in mm**
- General purpose tolerance – **a tolerance class that includes a tolerance position and a tolerance grade for both pitch diameter and minor diameter**

Basic metric thread note



Complete threading - metric system

Tolerance specified



- The number of the tolerance grades reflects the size of the tolerance
- For example, grade 4 < grade 6 < grade 8 tolerances
- In addition to the tolerance grade, a positional tolerance is required
- For external threads:
 - Tolerance position e (large allowance)
 - Tolerance position g (small allowance)
 - Tolerance position h (no allowance)
- For internal threads:
 - Tolerance position G (small allowance)
 - Tolerance position H (no allowance)

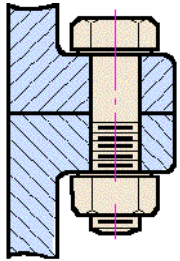
TPI for various UN forms

ANSI

Sizes		Basic Major Diameter	Series with Graduated Pitches
Primary	Secondary		Coarse UNC
3		0.0600	--
	1	0.0730	64
2		0.0860	56
	1/2	0.0990	48
4		0.1120	40
5		0.1260	40
3		0.1000	32
3		0.1040	32
10		0.1900	24
	1/2	0.2500	20
5H/3		0.3125	16
3/0		0.3750	16
7/16		0.4375	14
1/2		0.500	12
3H/8		0.5625	12
5/8		0.6250	11
3	1/16	0.6875	10
10	3/16	0.7500	10
	1/2	0.8125	--
1/2	1/2	0.8750	9
5H/8		0.9375	--
3/0		1.0000	8
7/16		1.0625	--
	1/16	1.1250	7
	1/8	1.1875	--
	1/4	1.2500	7
	3/16	1.3125	--
	1/2	1.3750	--
	3/8	1.4375	--
	1/2	1.5000	6
	5/8	1.5625	--
	3/4	1.6250	--
	1 1/16	1.6875	--
	3/4	1.7500	5
	1 1/8	1.8125	--
	7/8	1.8750	--
	1 1/4	1.9375	--
2		2.0000	4
	1 1/2	2.0625	--
2 1/4		2.1250	--
	1 3/8	2.1875	--
	1 1/2	2.2500	4
	1 3/4	2.3125	--
	2	2.3750	--
	2 1/2	2.4375	--
	2 3/4	2.5000	4
	3	2.5625	--
	3 1/4	2.6250	--
	3 1/2	2.6875	--
	3 3/4	2.7500	4
	4	2.8125	--

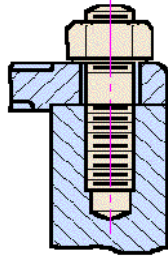
Sizes		Basic Major Diameter	Threads per Inch										Size		
Primary	Secondary		Series with Graduated Pitches			Series with Constant Pitches									
			Coarse UNC	Fine UNF	Extra Fine UNEF	1UN	1.5UN	2UN	2.5UN	3UN	3.5UN				
3		0.0600	--	30	--	--	--	--	--	--	--	--	--	3	
	1	0.0730	64	72	--	--	--	--	--	--	--	--	--	1	
2		0.0860	56	64	--	--	--	--	--	--	--	--	--	2	
	1/2	0.0990	48	56	--	--	--	--	--	--	--	--	--	1/2	
4		0.1120	40	48	--	--	--	--	--	--	--	--	--	4	
5		0.1260	40	44	--	--	--	--	--	--	--	--	--	5	
3		0.1000	32	40	--	--	--	--	--	--	--	--	UNC	3	
3		0.1040	32	36	--	--	--	--	--	--	--	--	UNC	3	
10		0.1900	24	32	--	--	--	--	--	--	--	--	UNC	10	
	1/2	0.2500	24	28	32	--	--	--	--	--	--	UNF	UNF	1/2	
1/2		0.2500	20	28	32	--	--	--	--	--	UNC	UNF	UNEF	1/2	
5H/3		0.3125	16	24	32	--	--	--	--	16	20	28	UNEF	5H/3	
3/0		0.3750	16	24	32	--	--	--	--	UNC	20	28	UNEF	3/0	
7/16		0.4375	14	20	25	--	--	--	--	16	UNF	JNEF	32	7/16	
1/2		0.500	12	20	25	--	--	--	--	16	UNF	JNEF	32	1/2	
3H/8		0.5625	12	18	24	--	--	--	--	JNC	16	20	28	3H/8	
5/8		0.6250	11	18	24	--	--	--	--	2	16	20	28	32	5/8
3	1/16	0.6875	--	24	--	--	--	--	--	2	16	20	28	32	11/16
3/4		0.7500	10	16	20	--	--	UNC	--	2	16	UNF	28	32	3/4
	3/16	0.8125	--	20	--	--	8	2	16	UNEF	28	32	32	13/16	8
7/8		0.8750	9	14	20	--	--	8	2	16	UNEF	28	32	7/8	
1	1/8	0.9375	--	20	--	--	8	2	16	UNF	28	32	32	15/16	8
1		1.0000	8	12	20	--	--	8	JNF	16	UNF	28	32	1	
1 1/8	1 1/16	1.0625	--	13	--	--	8	2	16	20	28	--	--	1 1/16	
1 1/8		1.1250	7	12	13	--	--	8	JNF	16	20	28	--	1 1/8	
1 1/4	1 3/16	1.1875	--	13	--	--	8	2	16	20	28	--	--	1 3/16	
1 1/4		1.2500	7	12	13	--	--	8	JNF	16	20	28	--	1 1/4	
1 1/2	1 5/16	1.3125	--	13	--	--	8	2	16	20	28	--	--	1 5/16	
1 1/2		1.3750	6	12	13	--	UNC	8	JNF	16	20	28	--	1 1/2	
1 1/2	1 7/16	1.4375	--	13	--	--	6	8	2	16	20	28	--	1 7/16	
1 3/4	1 1/2	1.5000	6	12	13	--	UNC	8	JNF	16	20	28	--	1 3/4	
1 3/4	1 9/16	1.5625	--	13	--	--	6	8	2	16	20	--	--	1 9/16	
2	3/4	1.6250	--	13	--	--	6	8	2	16	20	--	--	2	
2	1 1/16	1.6875	--	13	--	--	6	8	2	16	20	--	--	1 1/16	
2	3/4	1.7500	5	--	--	--	6	8	2	16	20	--	--	2	
2 1/4	1 1/2	1.8125	--	--	--	--	6	8	2	16	20	--	--	1 1/2	
2 1/4	7/8	1.8750	--	--	--	--	6	8	2	16	20	--	--	7/8	
2 1/2	1 5/8	1.9375	--	--	--	--	6	0	2	16	20	--	--	1 5/8	
2 1/2	2	2.0000	4	12	--	--	6	8	2	16	20	--	--	2	
2 3/4	2 1/8	2.1250	--	--	--	--	6	8	2	16	20	--	--	2 1/8	
2 3/4	1 3/4	2.1875	--	--	--	--	6	8	2	16	20	--	--	1 3/4	
2 3/4	2 3/8	2.2500	--	--	--	--	6	8	2	16	20	--	--	2 3/8	
2 3/4	2 1/2	2.3125	--	--	--	UNC	6	8	2	16	20	--	--	2 1/2	
2 3/4	2 5/8	2.3750	--	--	--	4	6	0	2	16	20	--	--	2 5/8	
2 3/4	2 3/4	2.4375	--	--	--	UNC	6	8	2	16	20	--	--	2 3/4	
2 3/4	2 7/8	2.5000	--	--	--	4	6	8	2	16	20	--	--	2 7/8	

Bolts, nuts and screws



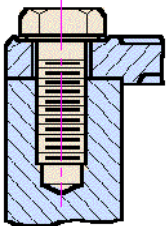
(A)

Bolt



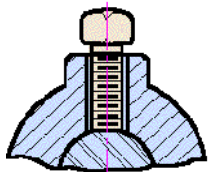
(B)

Stud



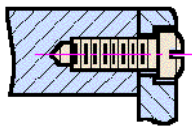
(C)

Cap Screw



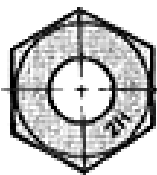
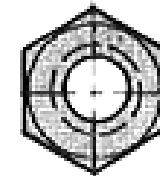
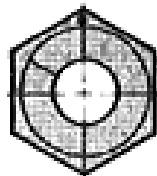
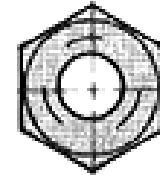
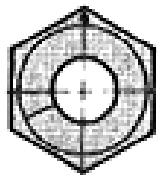
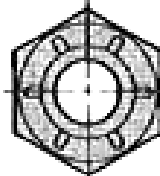
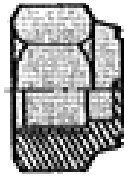
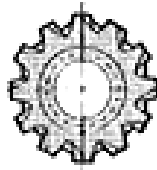
(E)

Set Screw



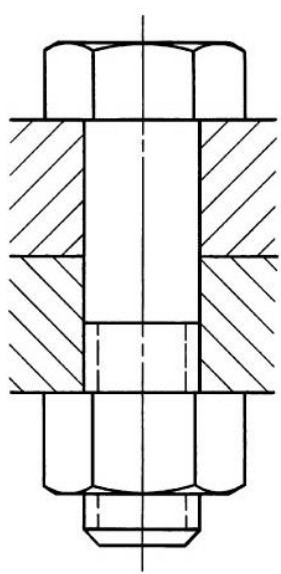
(D)

Machine Screw

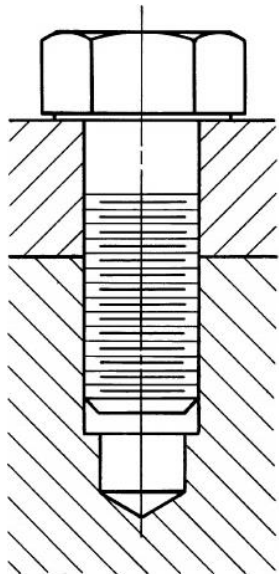


Bolts, nuts and screws

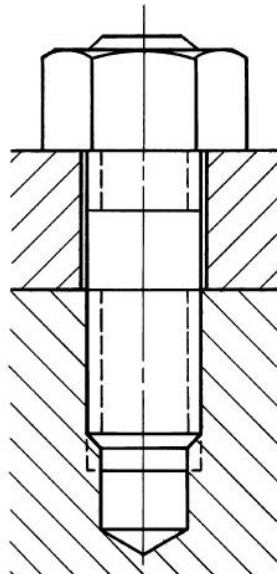
- Large variety of bolts (dimensional, head shape, etc.)
- Material, quality, finishing
- Grade



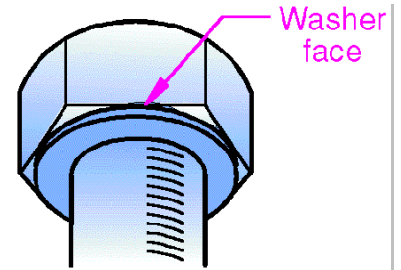
(a) BOLT



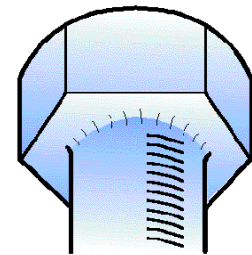
(b) CAP SCREW



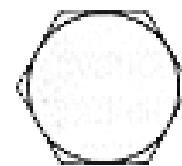
(c) STUD



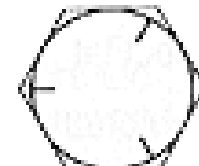
Semifinished
and finished



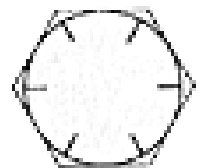
Unfinished



GRADE 2



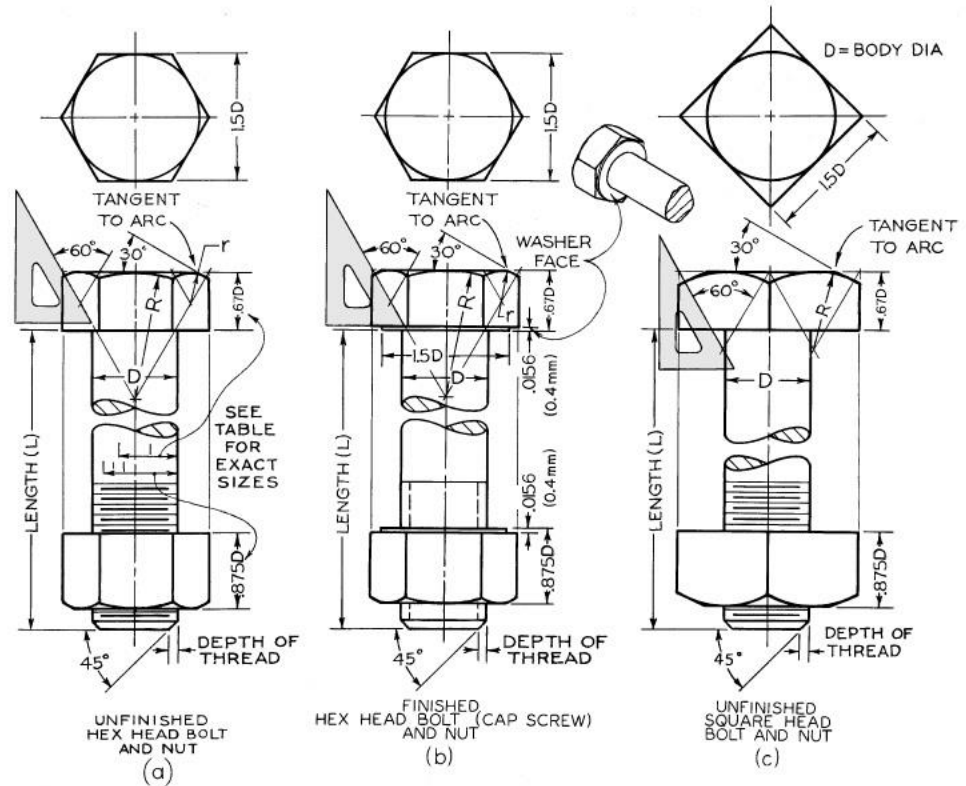
GRADE 5



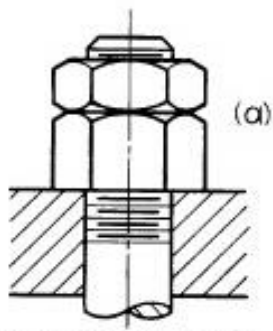
GRADE 8

Bolts, nuts and screws

- Unfinished bolts are not machined anywhere except for the thread portion
- Finished bolts have machined face for washer holding or flush location on parts

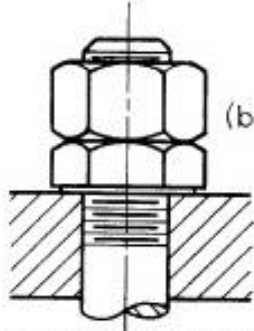


Fastener locking



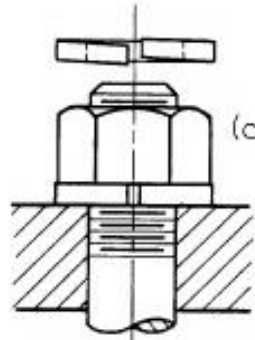
(a)

REGULAR UNFINISHED
JAM NUT (AMER STD)

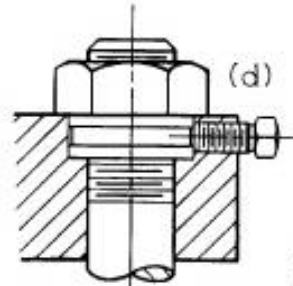


(b)

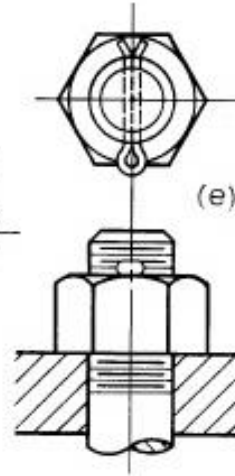
REGULAR SEMI-FINISHED
JAM NUT (AMER STD)



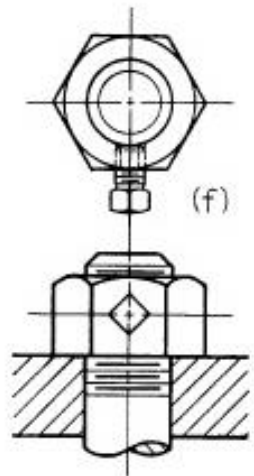
(c)



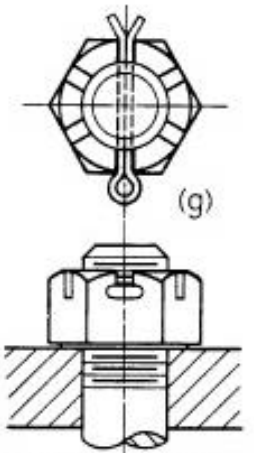
(d)



(e)

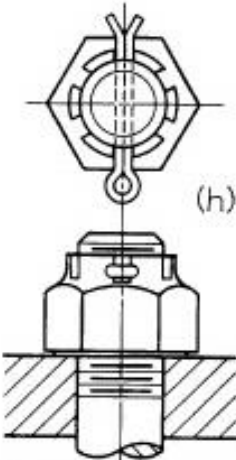


(f)



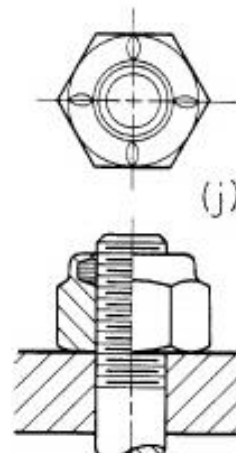
(g)

FINISHED SLOTTED
NUT (AMER STD)



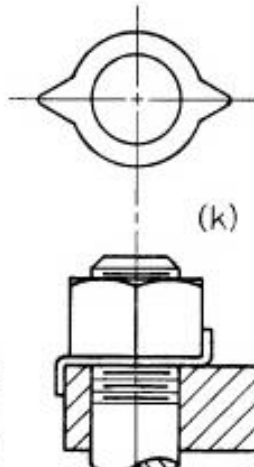
(h)

FINISHED CASTLE
NUT (AMER STD)

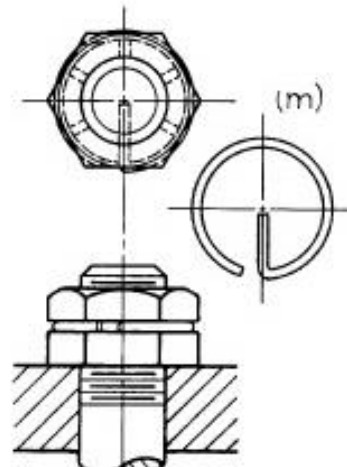


(j)

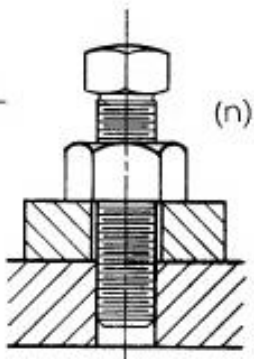
ESNA
STOP NUT



(k)

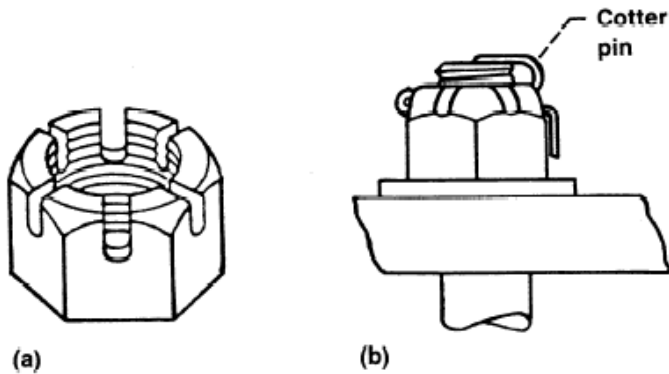


(m)



(n)

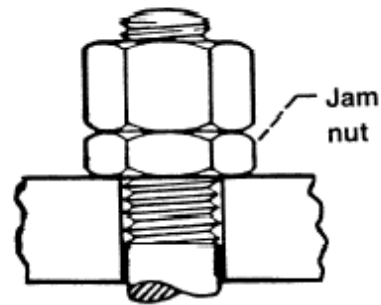
Fastener locking



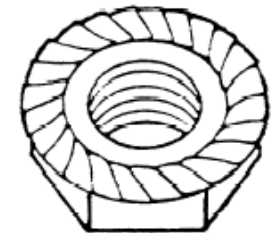
(a) Slots.

(b) Cotter pin locking.

Castellated nut



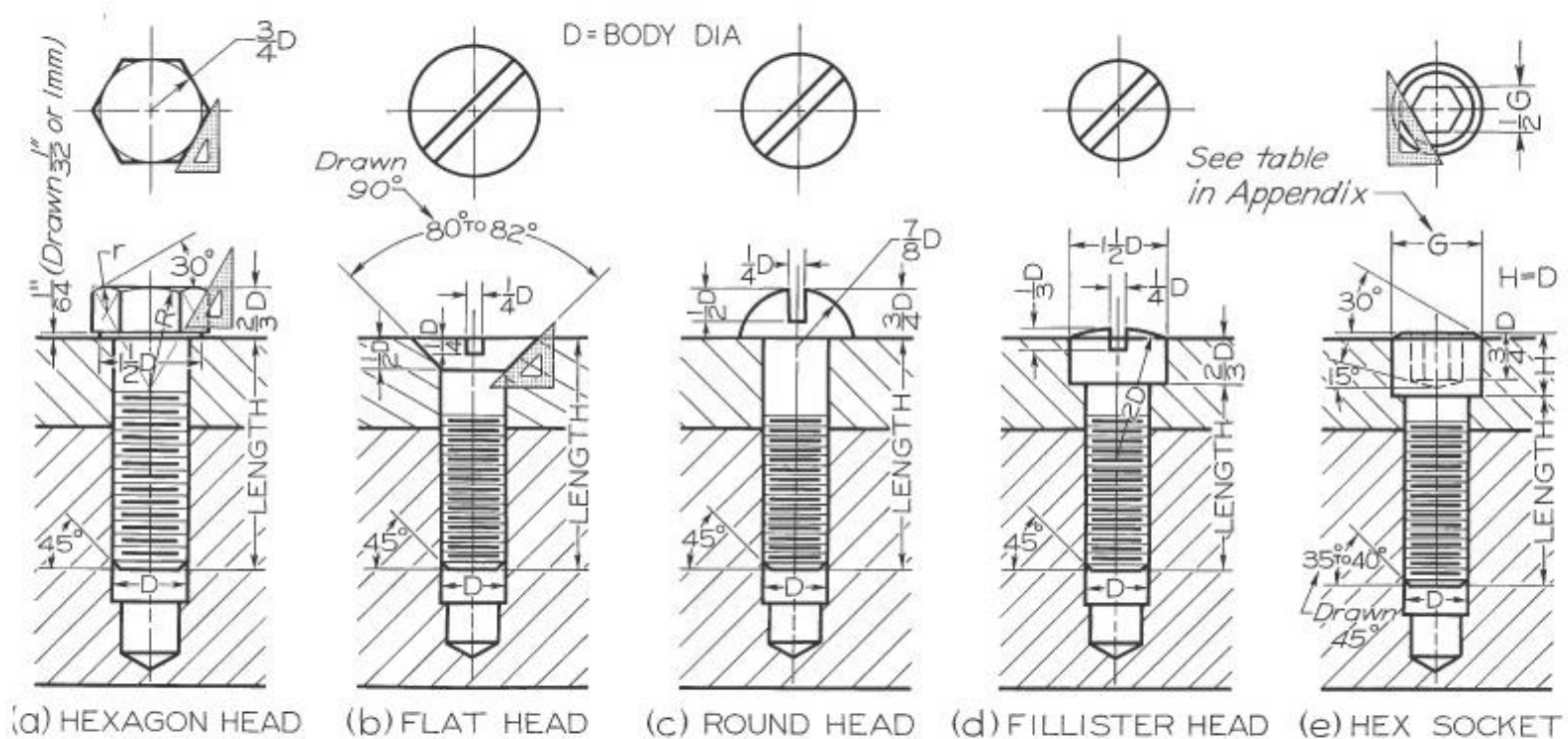
Jam nut



Durlock nut

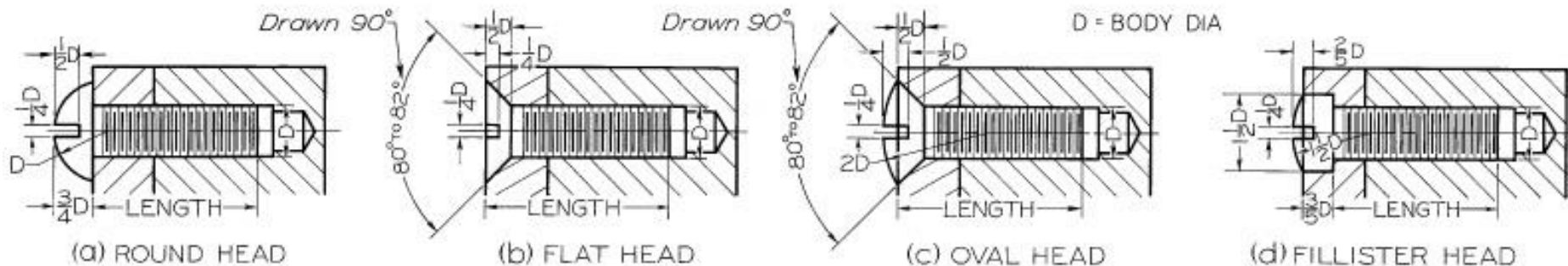
Standard Cap Screws

- 5 different capscrews shown. Socket head can have different shapes of head and sockets
- Sued in machines to pass through clearance hole to screw into another and improve appearance
- Socket screws are used while in crowded condition

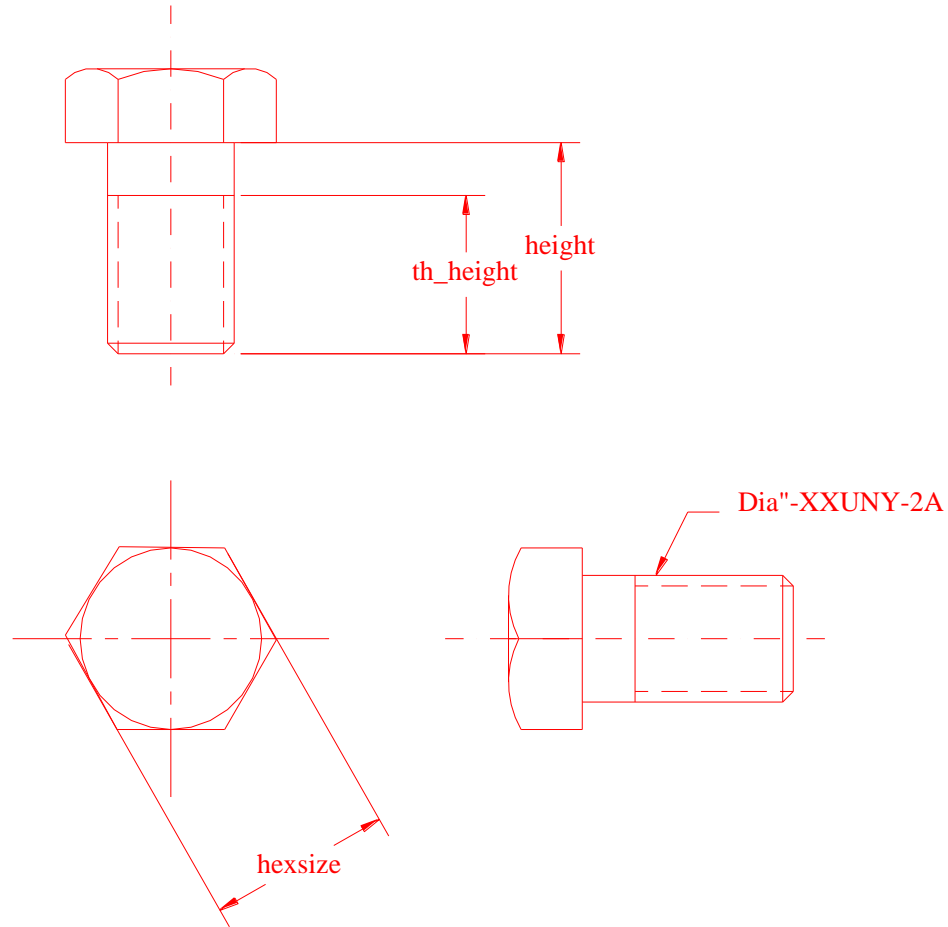


Standard Cap Screws

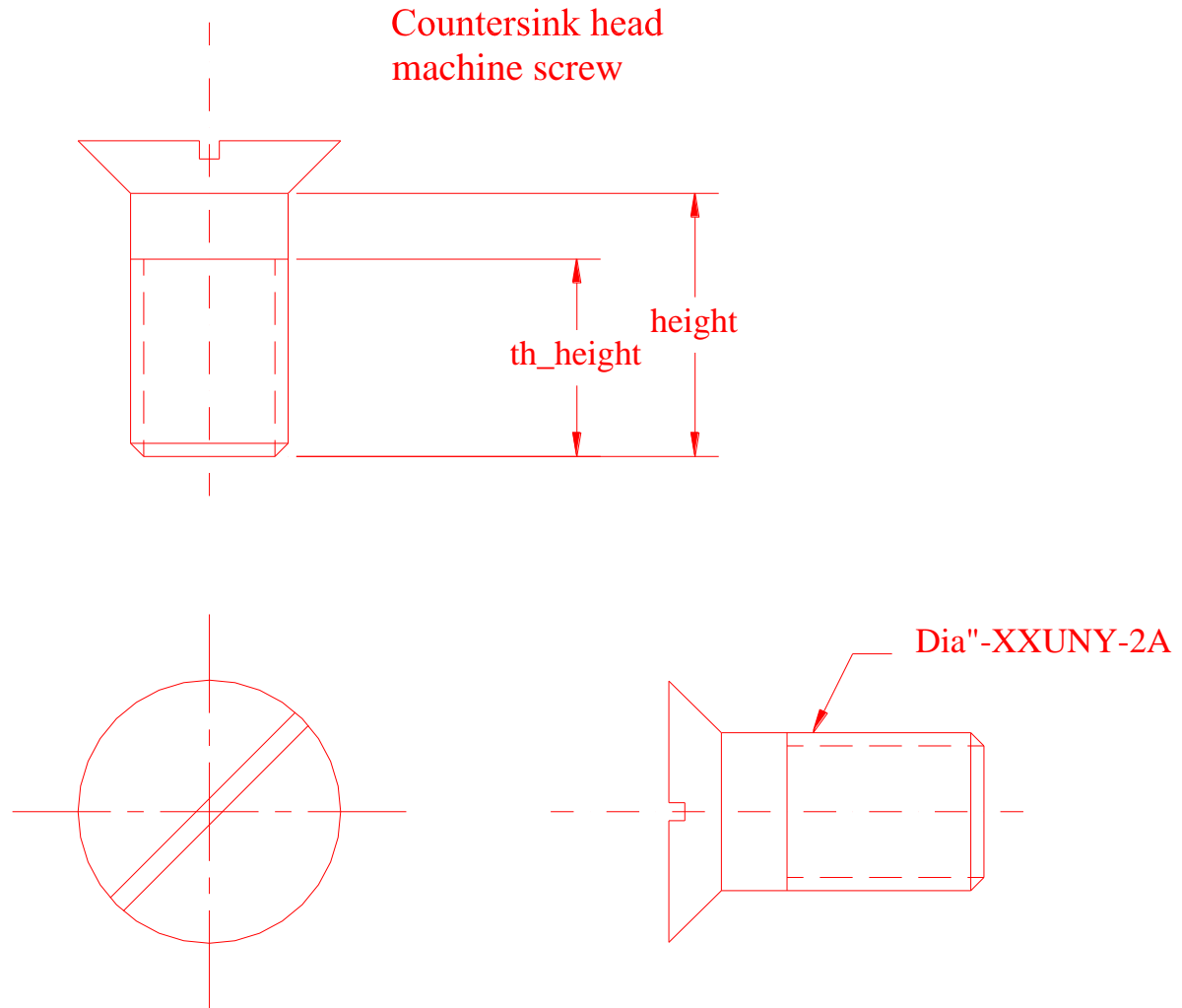
- Similar to cap screws but smaller in size.
- General diameters between .06 to .75 inches
- Hex head (not shown here) may be slotted if desired
- Other heads are available as either slotted or recessed
- Generally used for screwing into thin materials



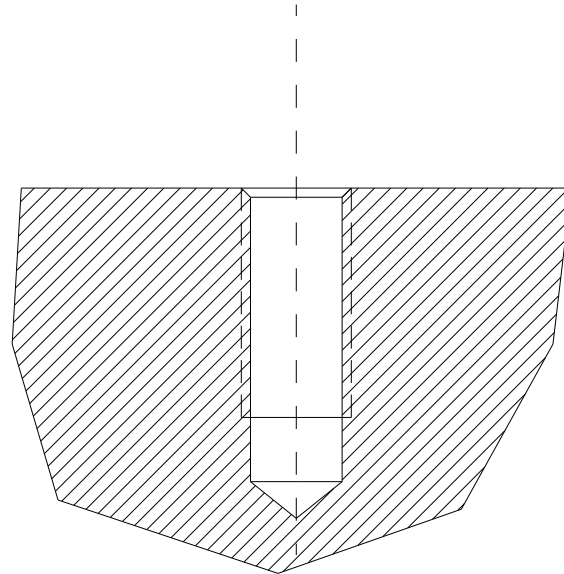
Part representation



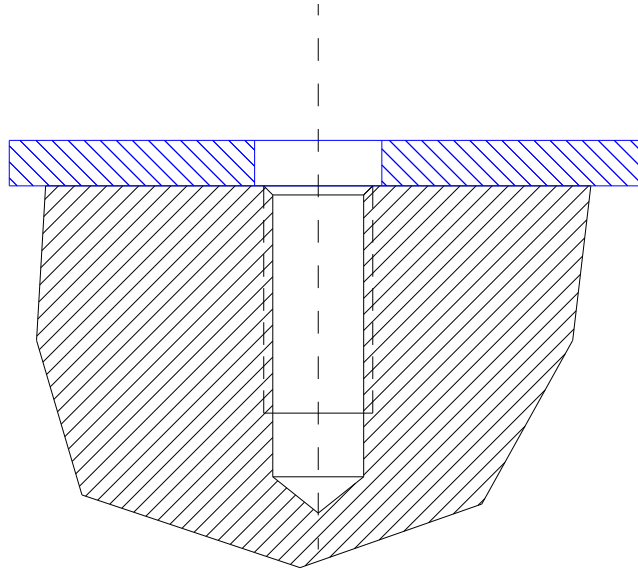
Part representation



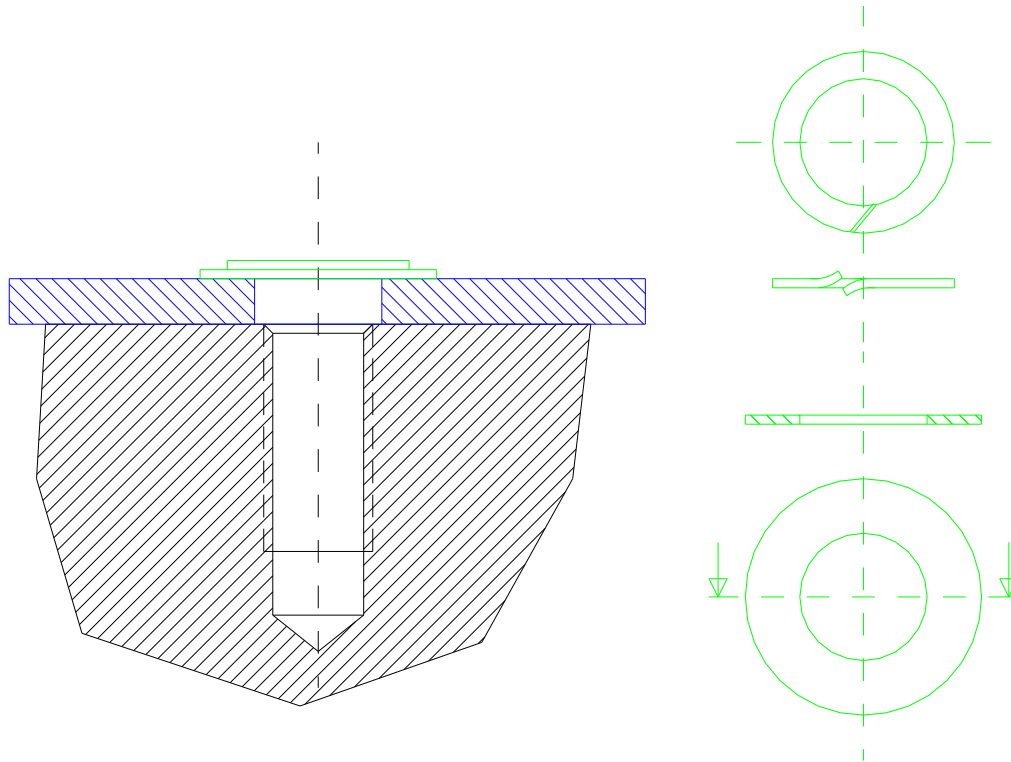
Assembly representation



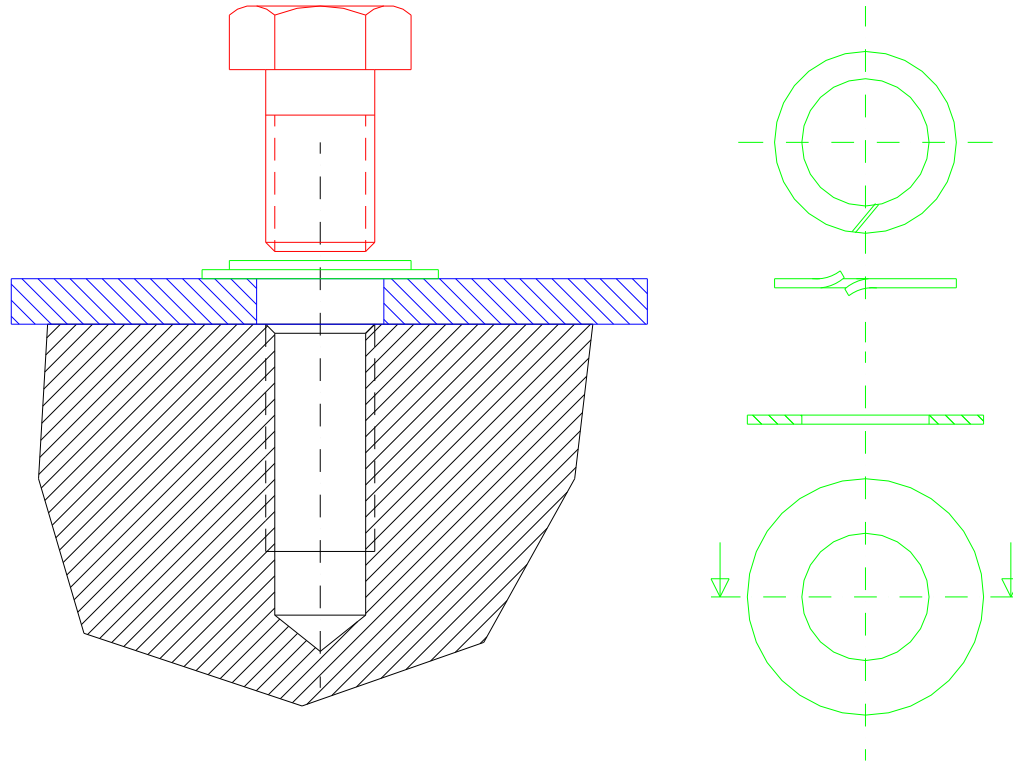
Assembly representation



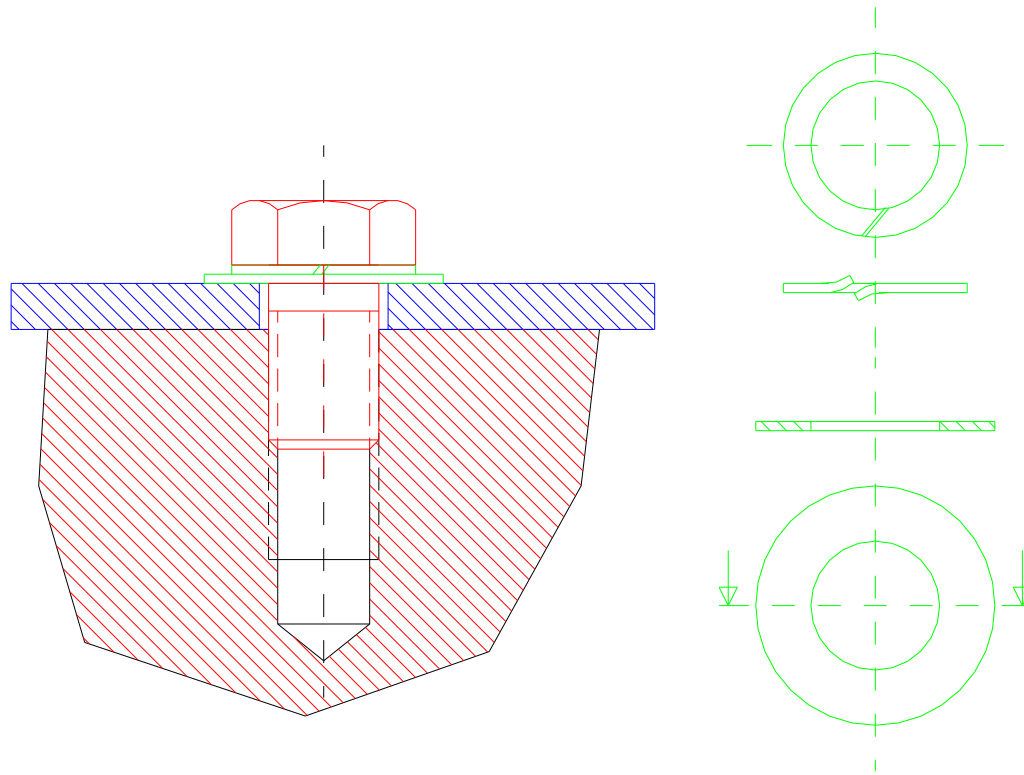
Assembly representation



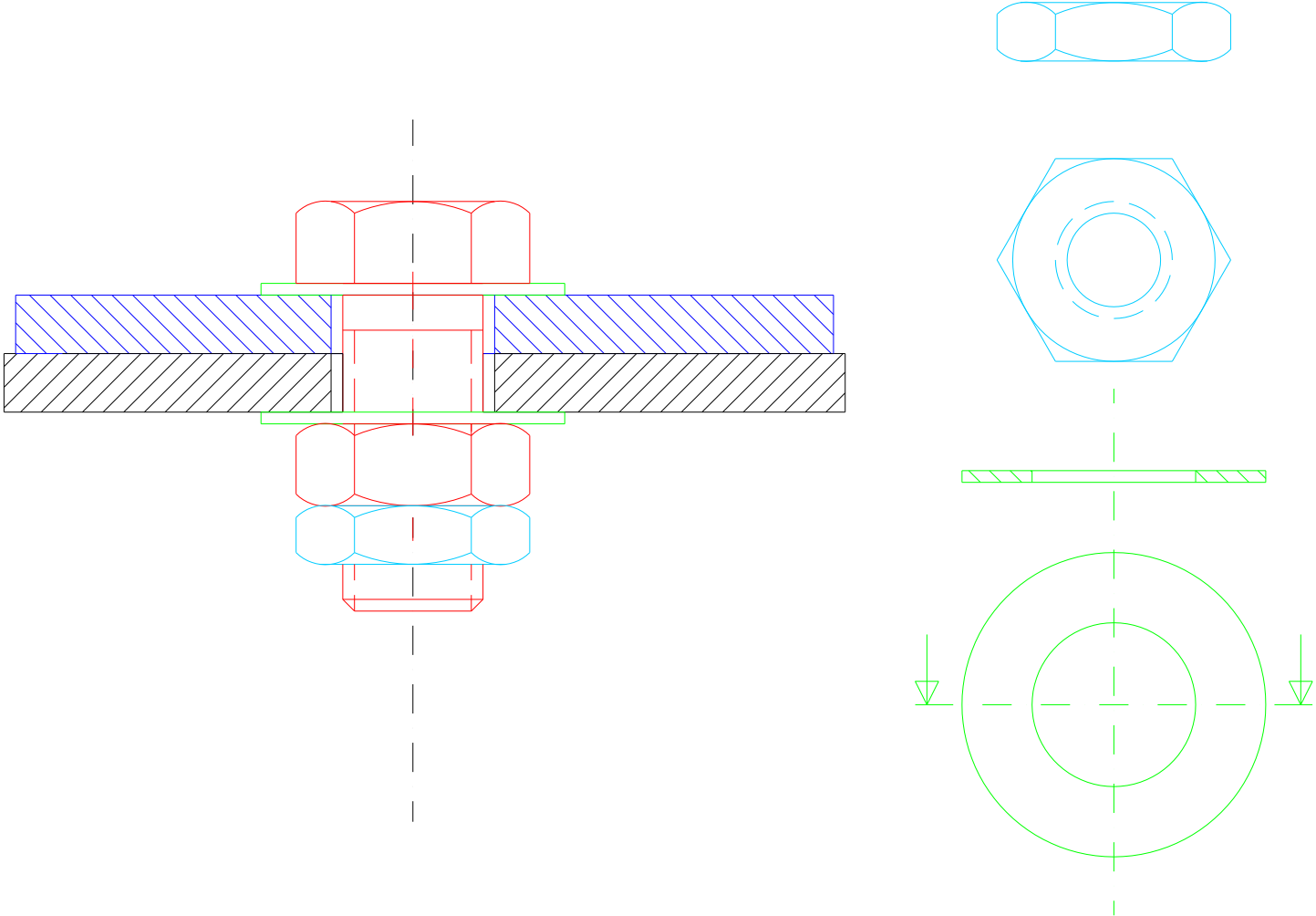
Assembly representation



Assembly representation

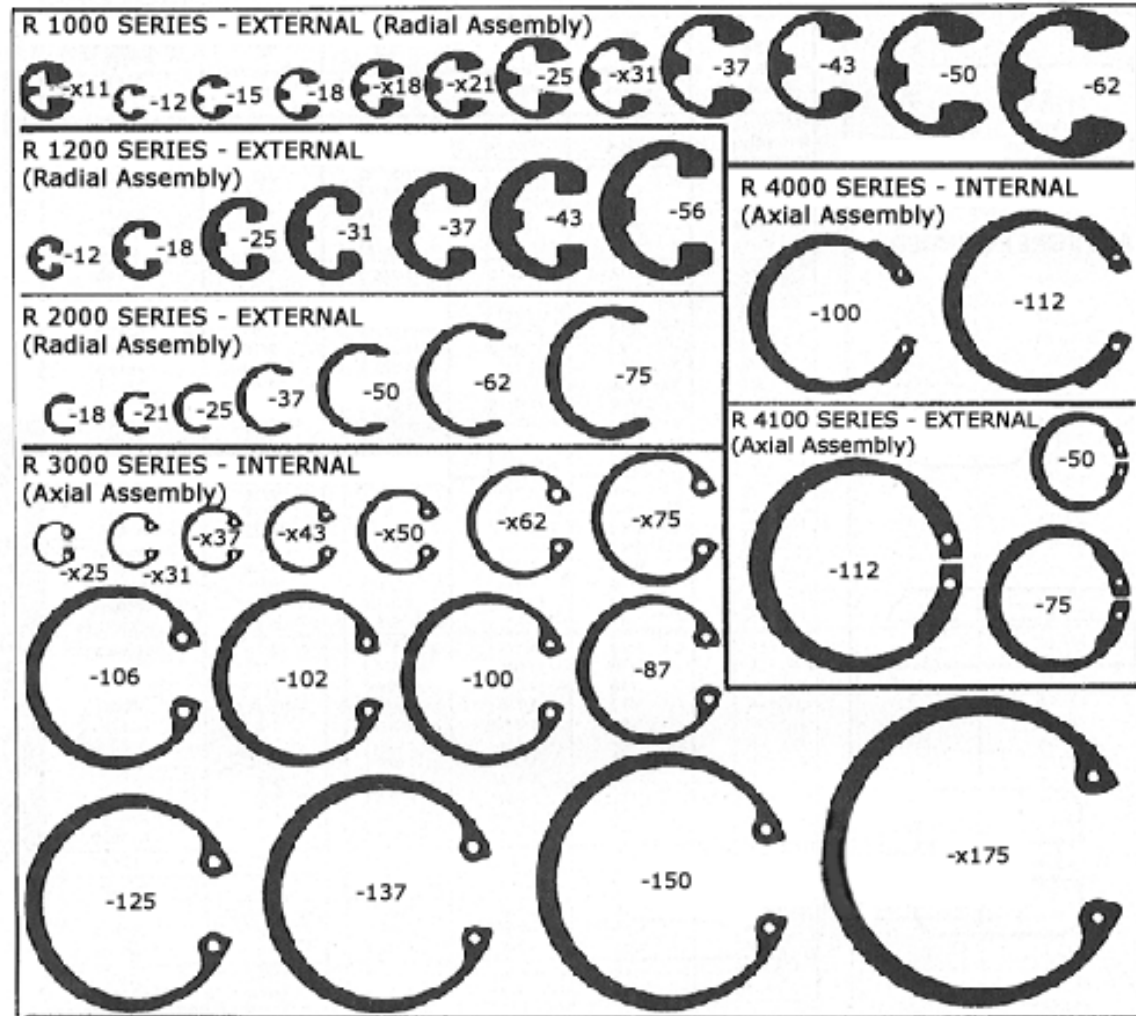


Assembly representation



Other non-permanent fasteners

- Clips, rings, pins, etc.

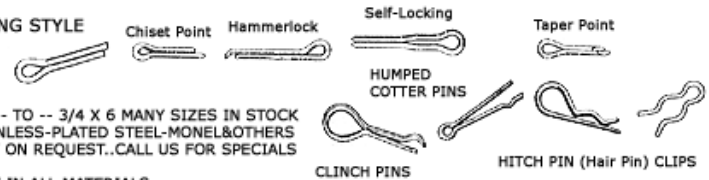


Other non-permanent fasteners

- Clips, rings, pins, etc.

COTTER PINS

STANDARD EXTENDED PRONG STYLE WITH SQUARE CUT ENDS



STANDARDS: FROM 1/32 X 1/4 -- TO -- 3/4 X 6 MANY SIZES IN STOCK
MATERIALS: STEEL-BRASS-STAINLESS-PLATED STEEL-MONEL&OTHERS
OTHER ITEMS: PRICE&DELIVERY ON REQUEST..CALL US FOR SPECIALS

NOT ALL STYLES ARE AVAILABLE IN ALL MATERIALS

DOWEL PINS

PRECISION GROUND



ALLOY STEEL & STAINLESS STEEL
1/16 X 1/4 TO 1 X 6 IN ALLOY
PULL DOWELS & OTHER MATERIALS AVAILABLE
(Manufactured to ANSI Standard B 18.8.2 1978)

WE CAN QUOTE ON SPECIALS, TO YOUR SPECS. CALL US!

SPRING PINS

EASILY INSTALLED ECONOMICAL
SELF-LOCKING LONG WEARING



AVAILABLE IN ROLLED, SLOTTED, SPLIT & TENSION
1/16 TO 1/2 DIAMETER AND METRIC SIZES
CARBON STEEL PLAIN AND PLATED
TYPE 302 & 420 STAINLESS STEEL

GROOVED PINS*

Positive holding action with six standard solid pin types and many specials.



Materials: Cold drawn low carbon steel is standard. Other materials available.

Finishes: Zinc electroplating is standard. Other finishes available.

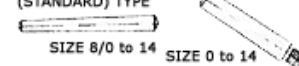
Sizes: 1/16" through 1/2" diameter
1/4" through 4 1/2" long.

High alloy, heat treated pins for extra shear, shock and fatigue resistance.

TAPER PINS*

COMMERCIAL (STANDARD) TYPE

TAPERED THREADED



TAPER IS 1/4" PER FOOT

CHECK WITH US FOR PRICES & AVAILABLE

Where disassembly of parts is expected, the taper pin, which can be easily driven out of its sized hole, is a useful fastening element. The cylindrical pin is made with a taper of 1/4" per foot measured on the diameter and with rounded or beveled ends to facilitate driving in reamed holes.

ESCUTCHEON PINS*

(DRIVE PINS)

ALL SIZES, BRASS & STEEL

MINIMUM ORDER QUANTITIES REQUIRED, CHECK WITH US.



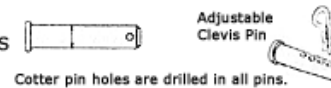
Commonly used for attaching nameplates and other light-duty fastening jobs, this pin has a hemispherical head at one end and a long cone or pinch point at the other. It is usually hammered into place by hand.

CLEVIS PINS*

ALL TYPES & ALL MATERIALS

COMMERCIAL & AIRCRAFT

STANDARD & SPECIAL



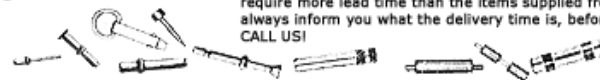
Cotter pin holes are drilled in all pins.

This headed, unthreaded pin is inserted into a prepared hole and locked in place with a cotter pin at the chamfered shank end. Disassembly is possible. Used extensively in both the aircraft and automotive industries.

CLEVIS PINS ARE AVAILABLE FROM THE SMALLEST 1/8" DIAMETER TO AS LARGE AS HOT FORGINGS WILL PERMIT, CARBON STEEL IS STANDARD UP TO 1".

SPECIAL PINS*

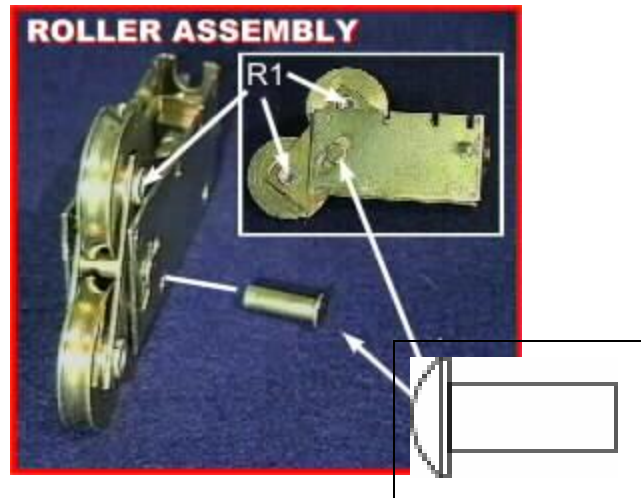
QUOTED TO YOUR SPECIFICATIONS & PRINTS.



*These items are supplied from our source factories. They will probably require more lead time than the items supplied from our stock. We will always inform you what the delivery time is, before you place your order, CALL US!

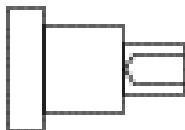
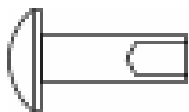
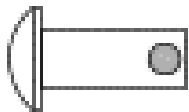
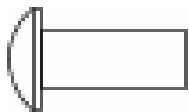
Permanent fasteners

- Once assembled, the parts of the assembly (including the fastener) would be destroyed to disassemble the assembly.
- Rivets, soldering, brazing, welding

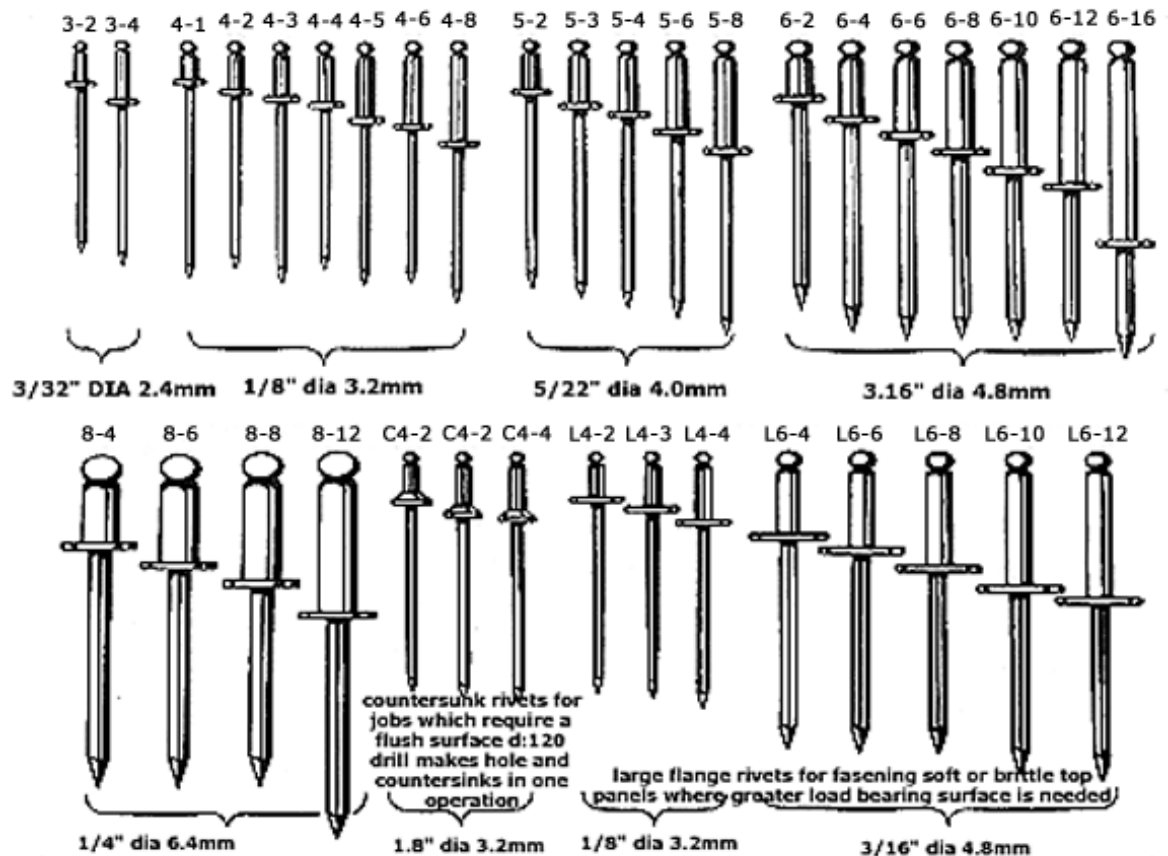


Rivets

- Used to permanently fasten mechanical components

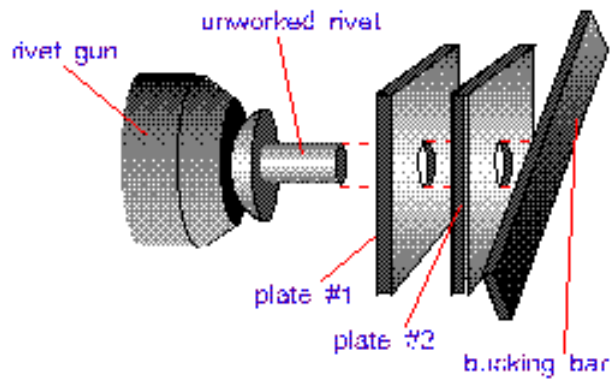


ACTUAL SIZE RIVET CHART

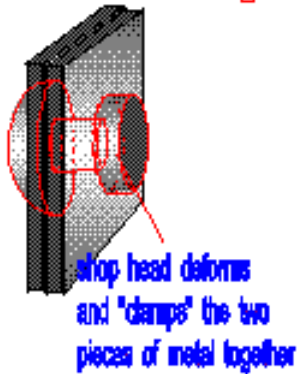


Riveting process

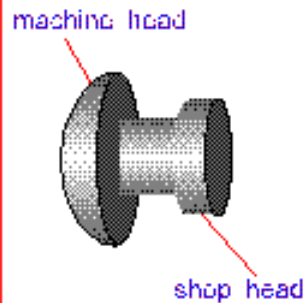
Before Bucking



After Bucking

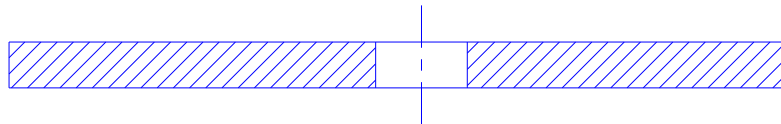


3-D View of a Bucked Rivet

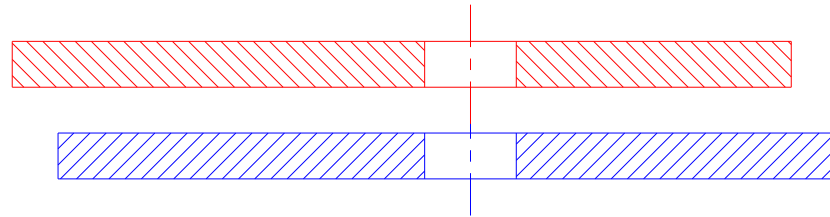


Fastening with rivets

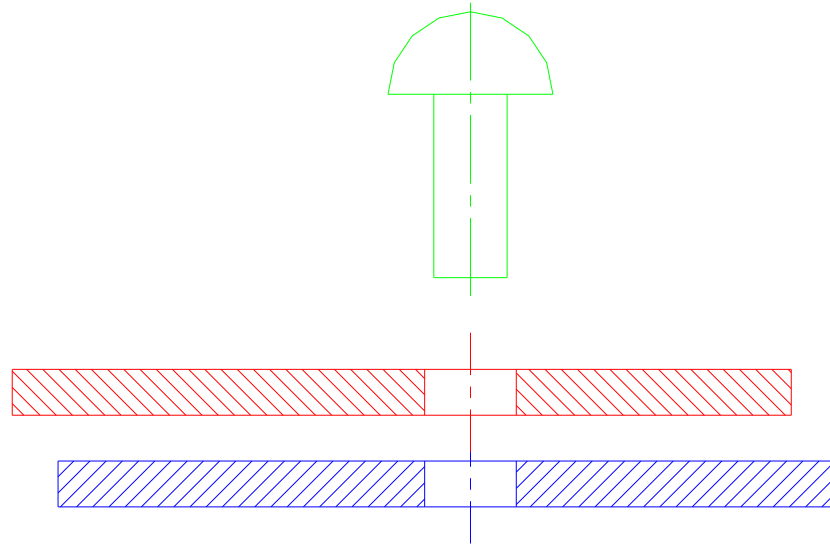
The headless end of the rivet is plastically deformed such that keeps together two components



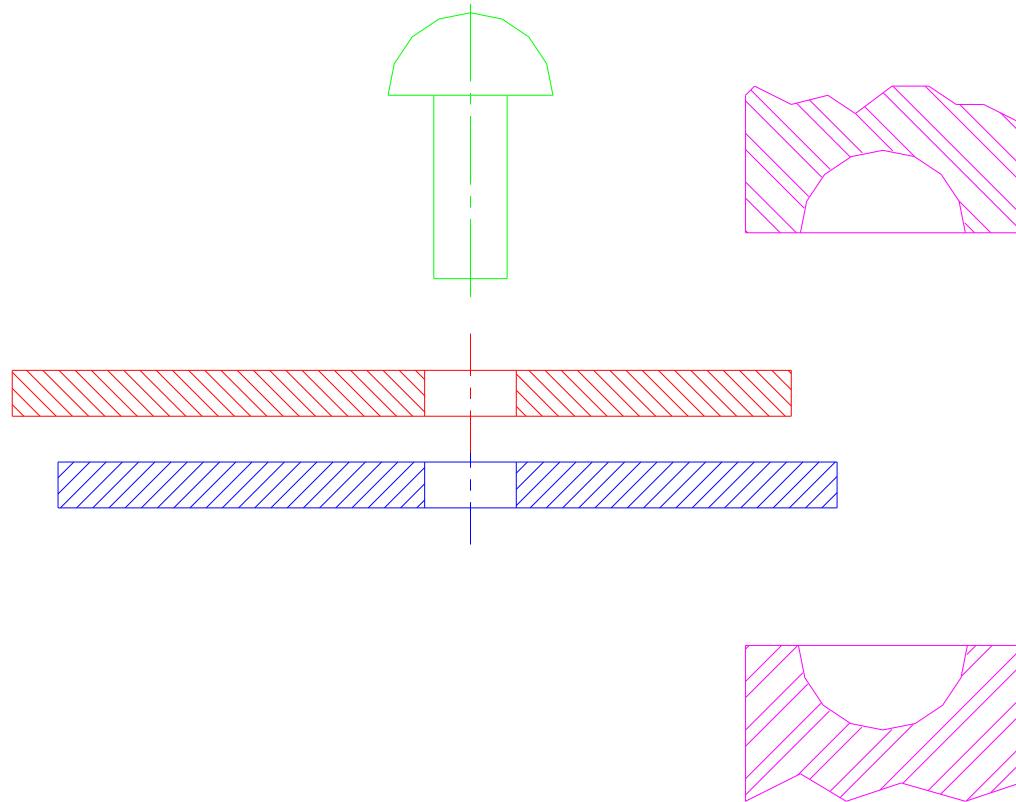
Fastening with rivets



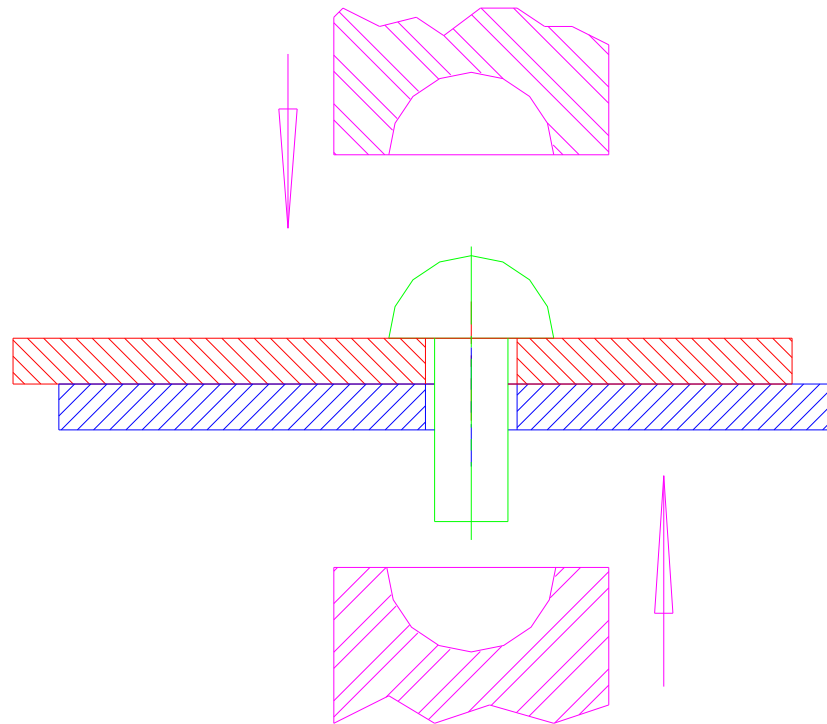
Fastening with rivets



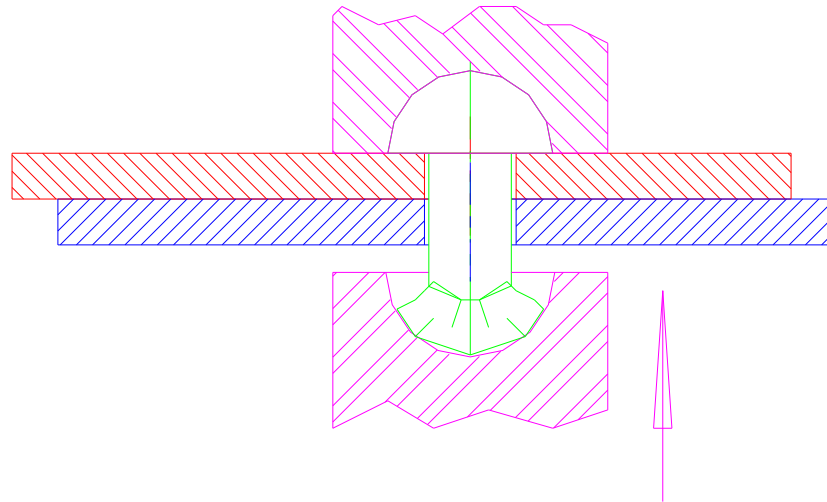
Fastening with rivets



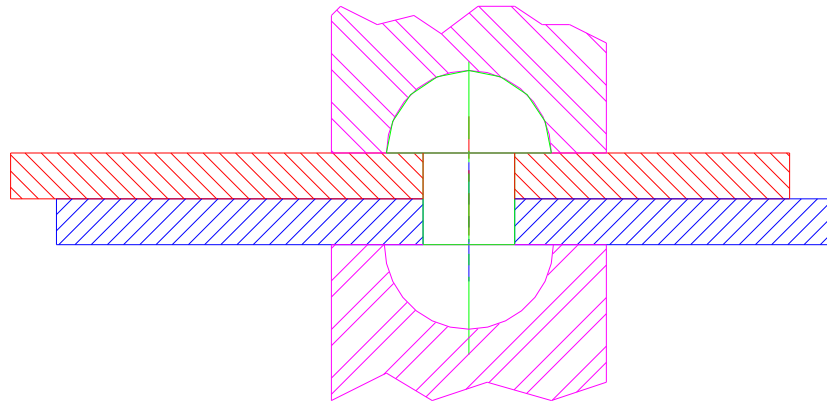
Fastening with rivets



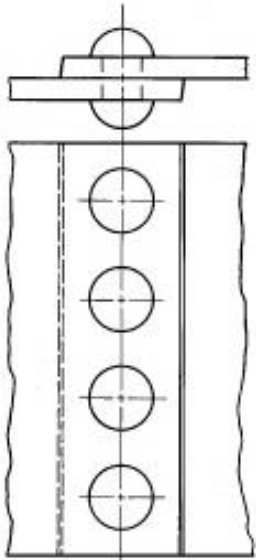
Fastening with rivets



Fastening with rivets

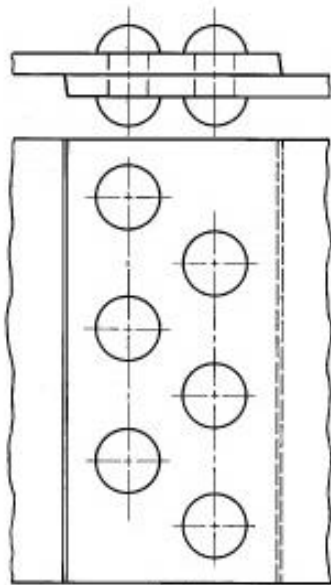


Common riveted joints



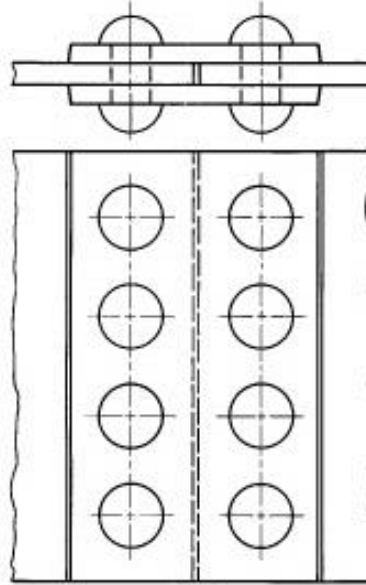
(a)

SINGLE RIVETED
LAP JOINT



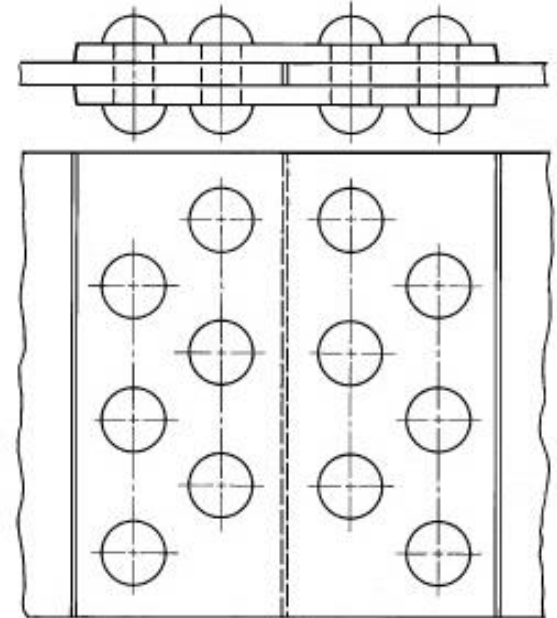
(b)

DOUBLE RIVETED
LAP JOINT



(c)

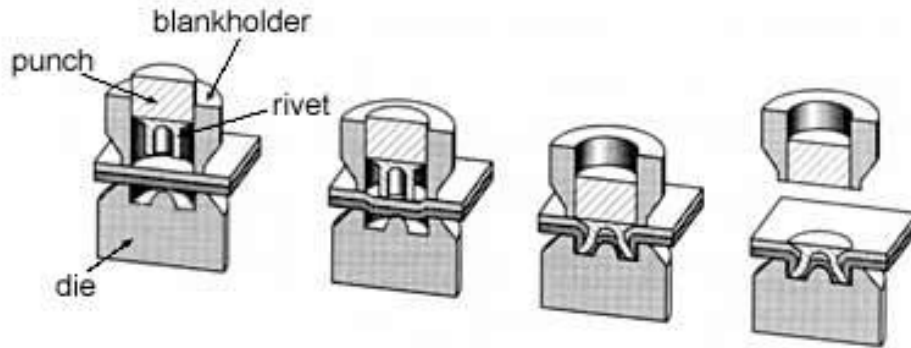
SINGLE RIVETED
BUTT JOINT



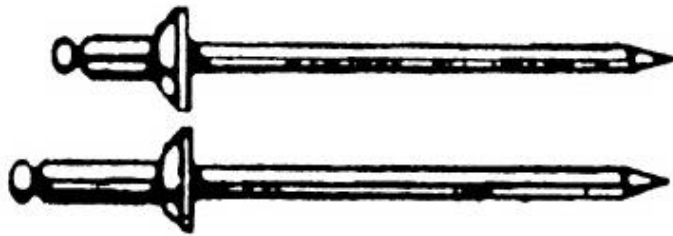
(d)

DOUBLE RIVETED BUTT JOINT

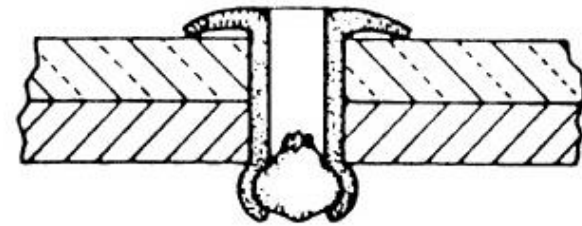
Self piercing rivets



Blind rivets



(a)



(b)

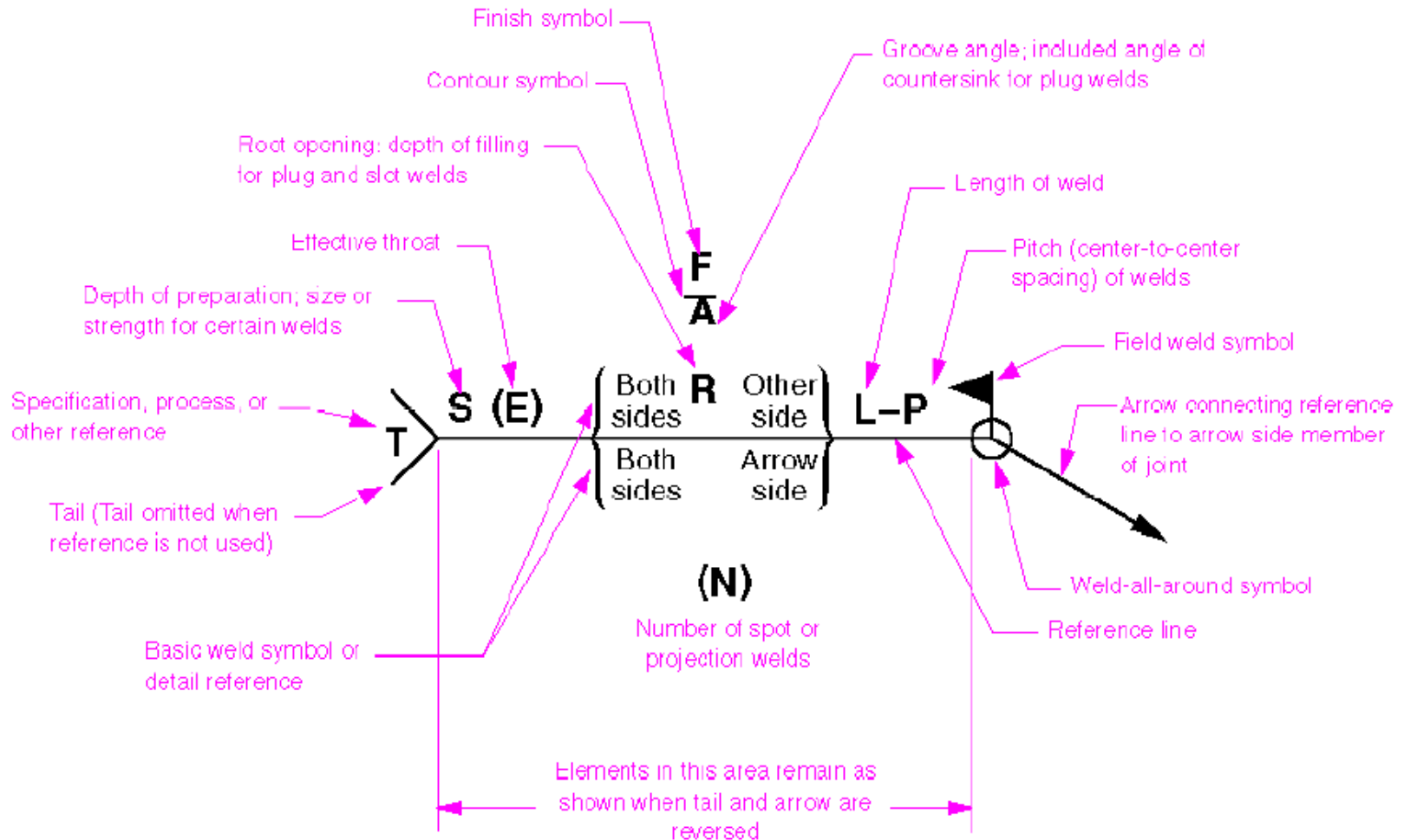
Soldering, brazing, welding

- Joining of two part using a third component – *filler* that joins the parts when in liquid state
- Soldering and brazing – low temperature binding materials – Sn-Pb, Cu-Ag alloys
- Limited capability to face thermo-mechanical loading

Welding

- Very well regulated activity
- It requires license to practice
- Welders bear significant responsibility
- The activity is based on rigorous rules and regulations
- Designer prescribe welding based on mechanics of materials calculations
- Symbols indicate the type of welding




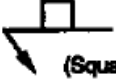




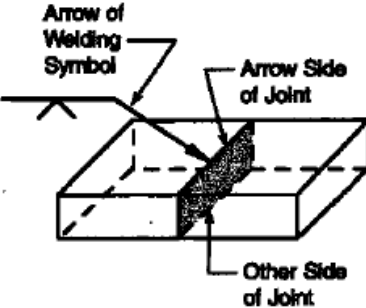
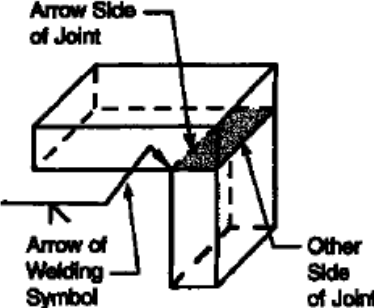
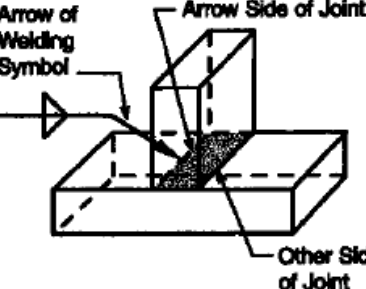
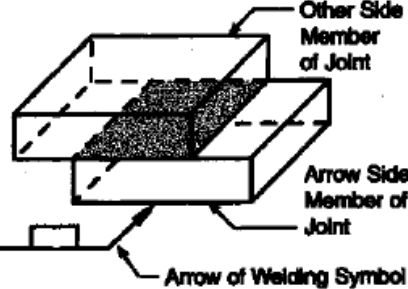
Basic welding symbol



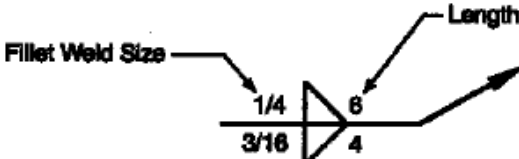
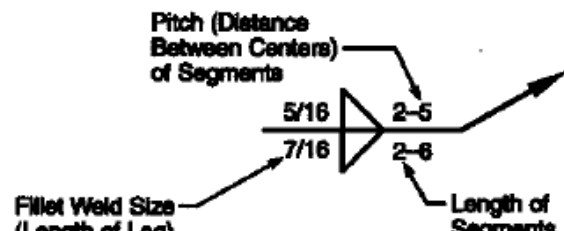
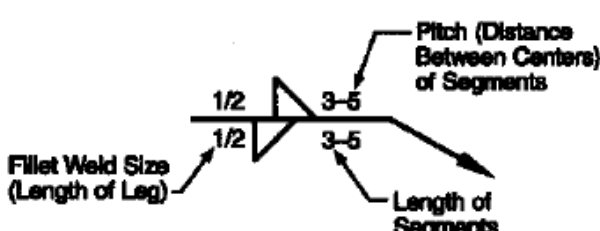
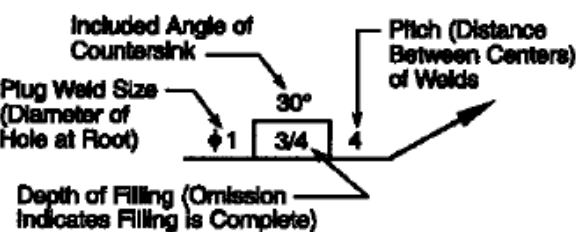
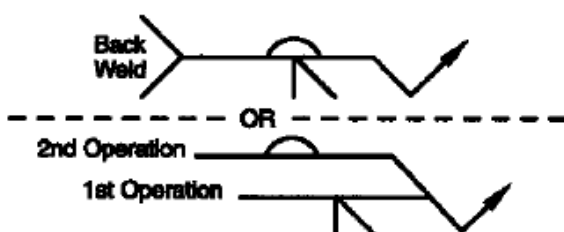
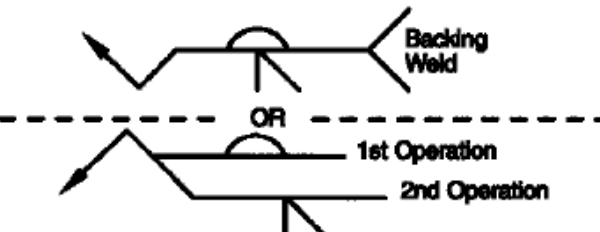
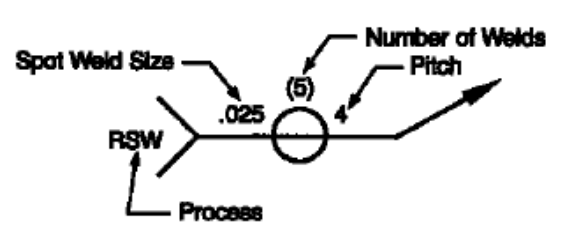
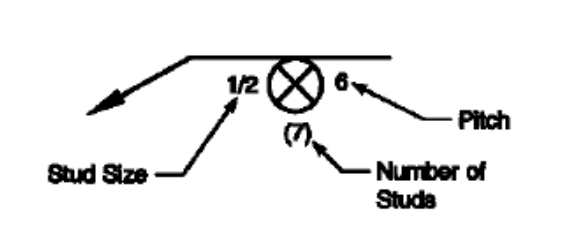
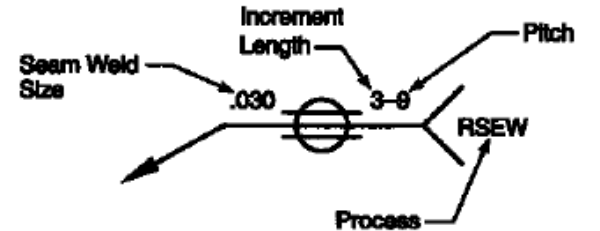
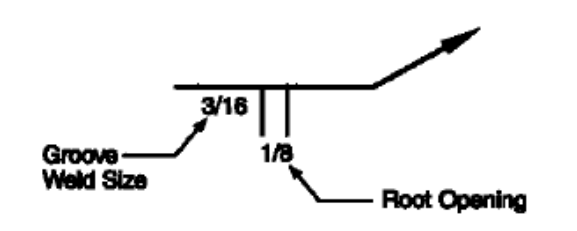
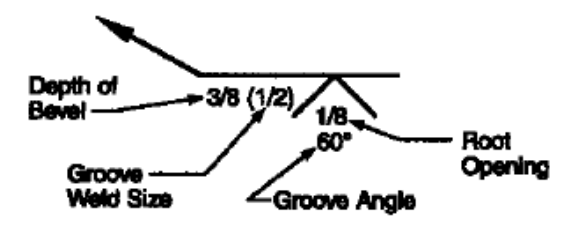
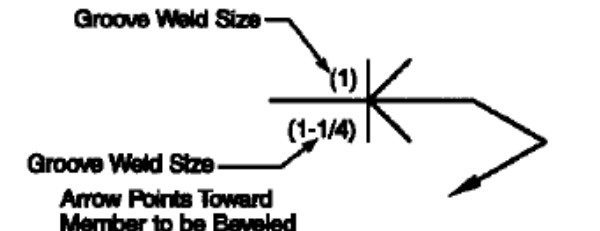
Basic welding symbols

Basic Welding Symbols and Their Location Significance								
Location Significance	Fillet	Plug or Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Edge
Arrow Side								
Other Side				Not Used			Not Used	
Both Sides		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	
No Arrow Side or Other Side Significance	Not Used	Not Used		Not Used		Not Used	Not Used	Not Used
Location Significance	Groove							Scarf for Brazed Joint
	Square	V	Bevel	U	J	Flare-V	Flare-Bevel	
Arrow Side								
Other Side								
Both Sides								

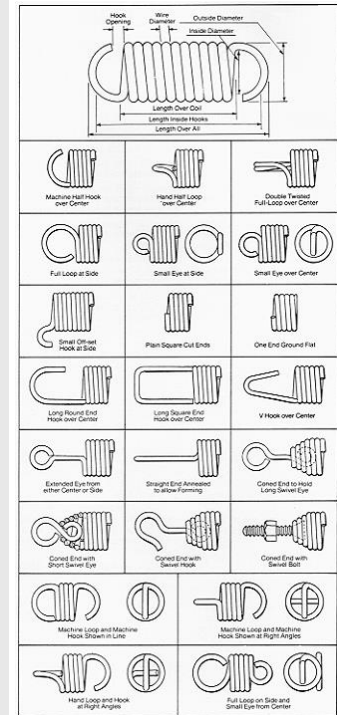
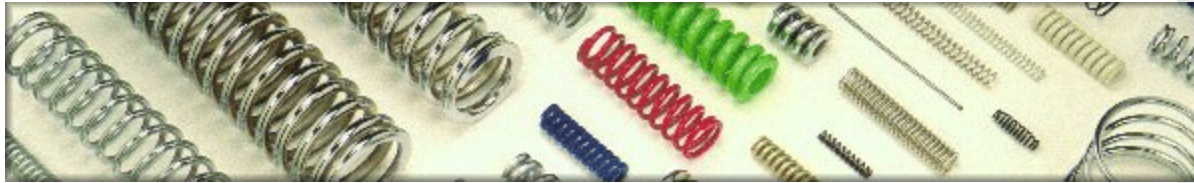
Basic welding symbols

Weld-All-Around	Field Weld	Melt-Thru	Consumable Insert
			 (Square)
Backing/Spacer (Rectangular)		Contour	
	Flush or Flat	Convex	Concave
			
Basic Joints			
Identification of Arrow Side and Other Side Joint			
Butt Joint		Corner Joint	
			
T-Joint		Lap Joint	
			

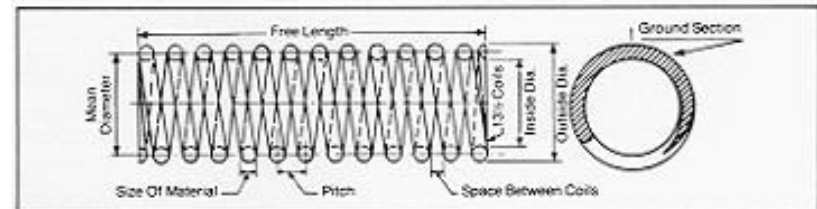
Basic welding symbols

<p>Double-Fillet Welding Symbol</p>  <p>Omission of Length indicates that Weld Extends Between Abrupt Changes in Direction or as Dimensioned</p>	<p>Chain Intermittent Fillet Welding Symbol</p> 	<p>Staggered Intermittent Fillet Welding Symbol</p> 
<p>Plug Welding Symbol</p> 	<p>Back Welding Symbol</p> 	<p>Backing Welding Symbol</p> 
<p>Spot Welding Symbol</p> 	<p>Stud Welding Symbol</p> 	<p>Seam Welding Symbol</p> 
<p>Square-Groove Welding Symbol</p> 	<p>V-Groove Welding Symbol</p> 	<p>Double-Bevel-Groove Welding Symbol</p> 

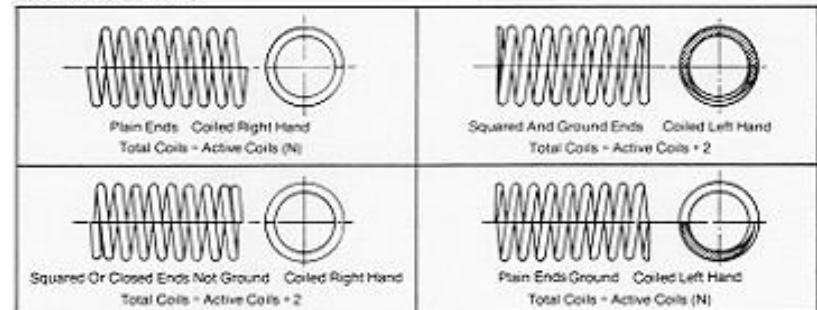
Springs



- Designed to store energy when deflected and return the same amount of energy when released
- Basically divided as **Helical** and **Flat** springs
- Helical springs are sub divided as
 - Compression Springs
 - Extension Springs
 - Torsion Springs

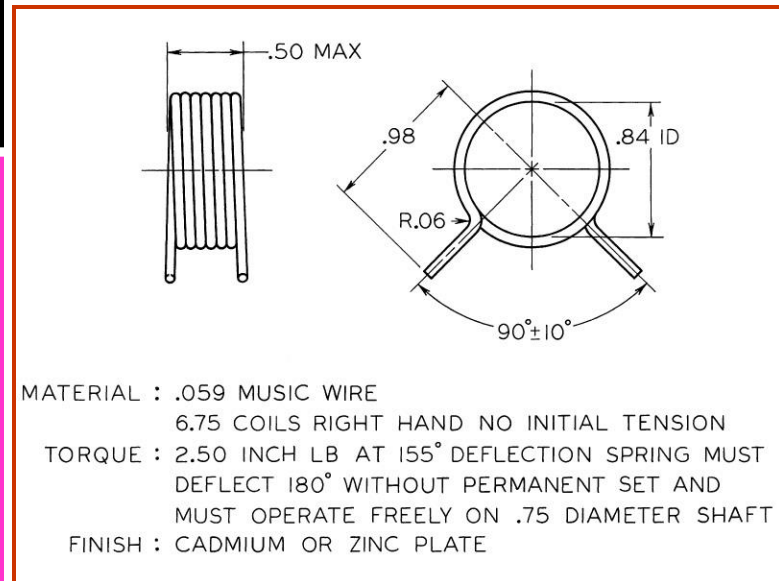
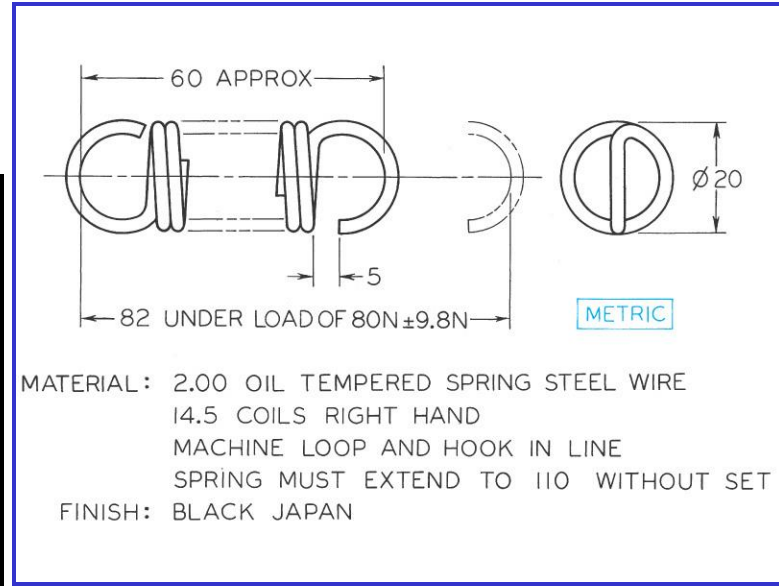
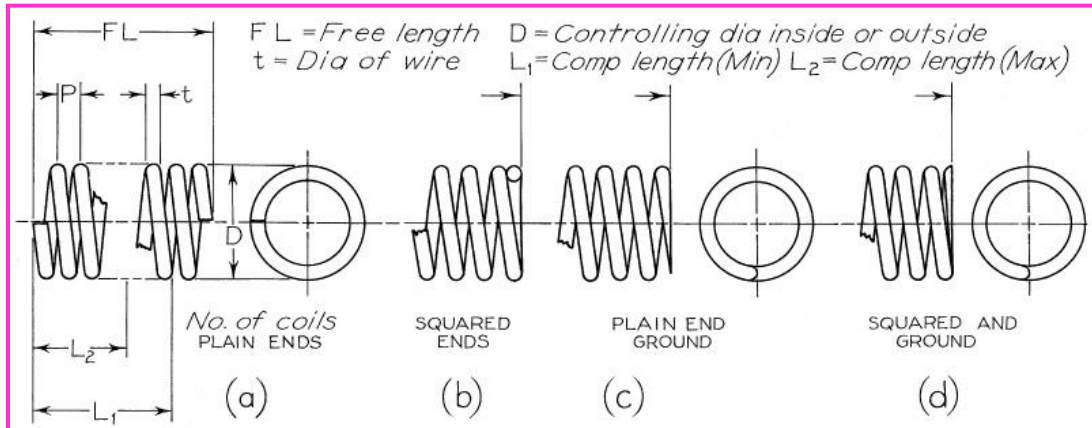
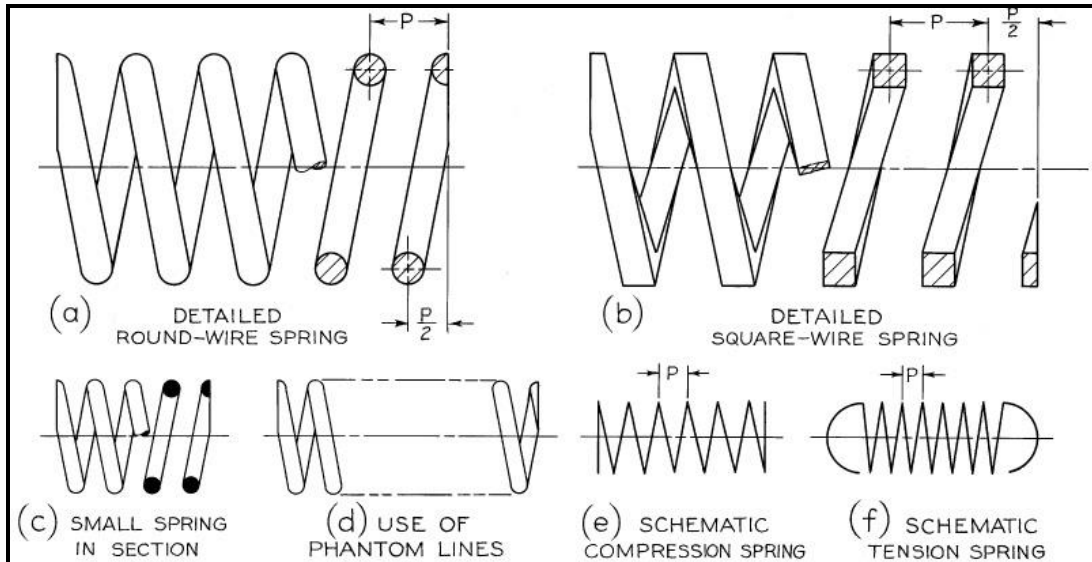


Type of End Finishes



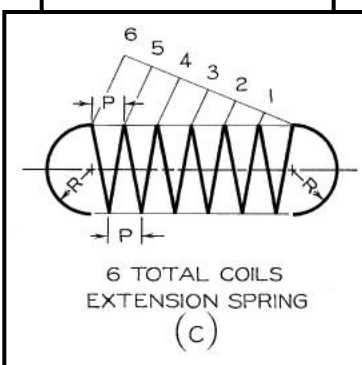
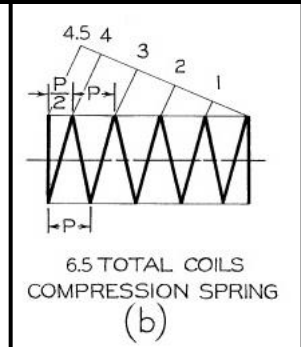
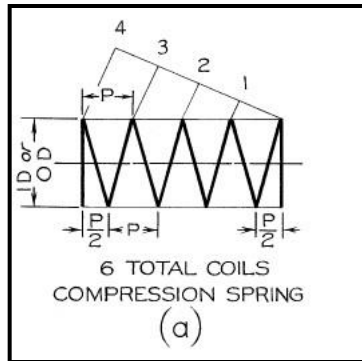
Helical Springs

Compression, Extension & Torsion

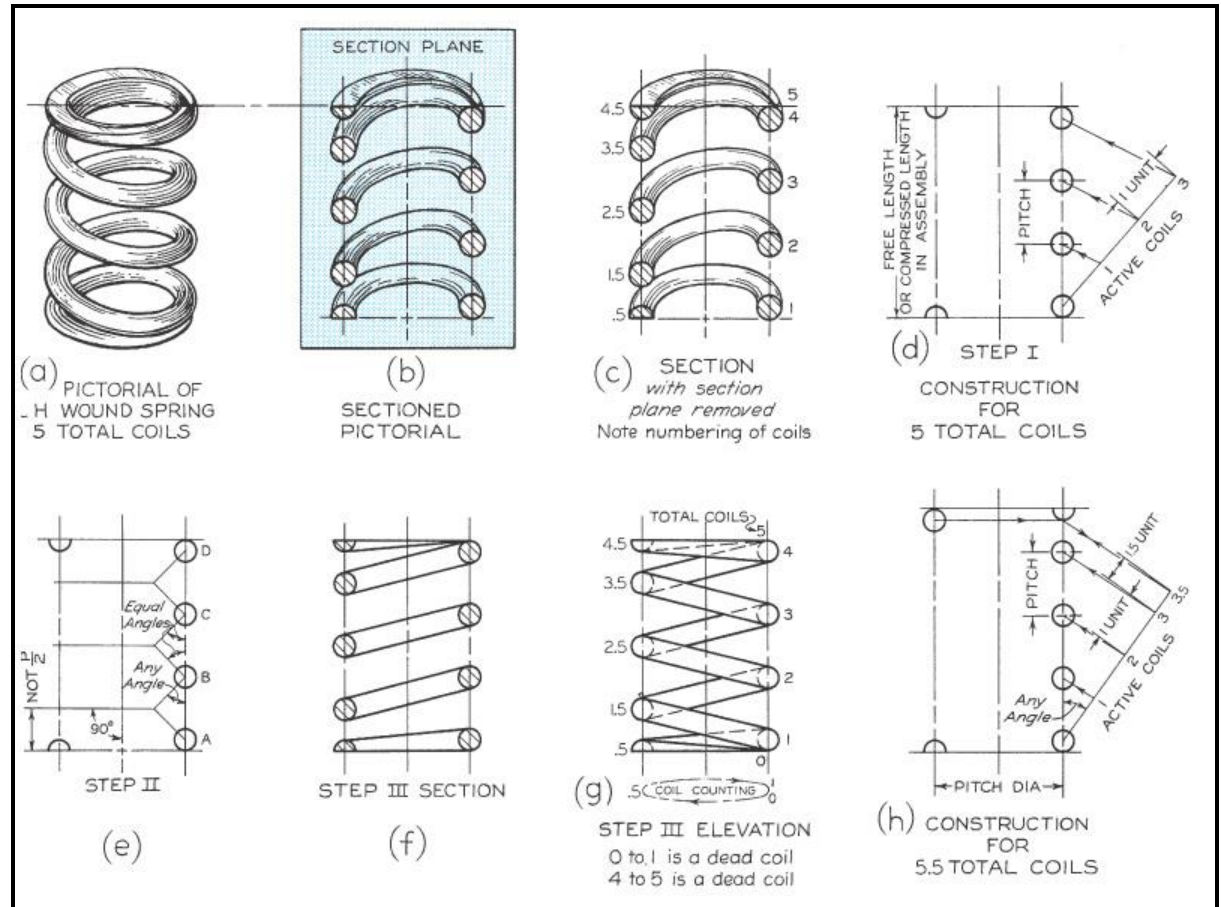


Spring representation

Schematic representation

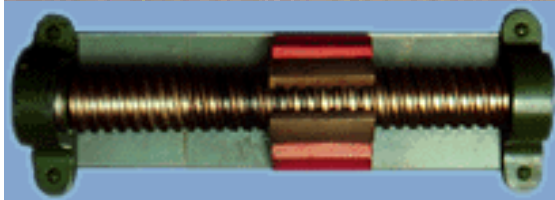
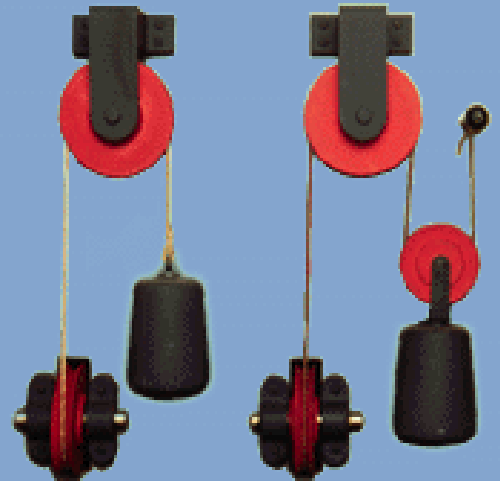


Detailed representation



Working drawing of a compression spring

Machine elements

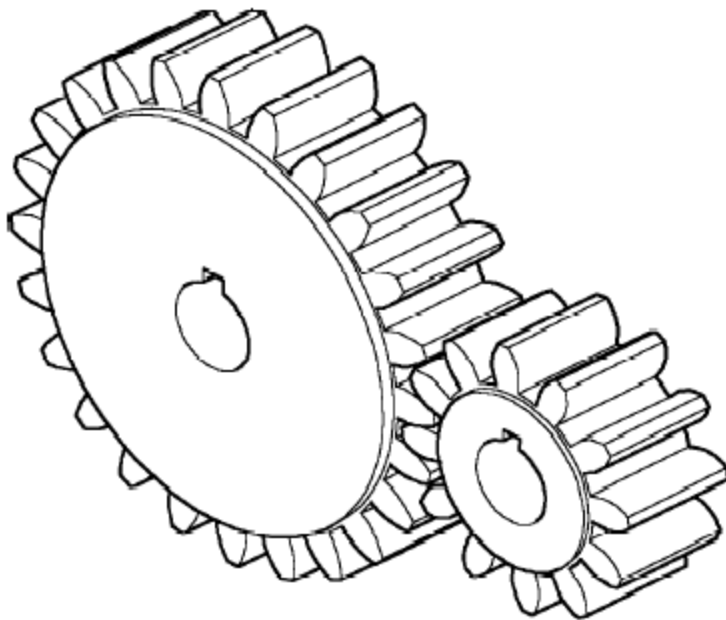


Machine elements

- Used to transmit power or support elements that transmit power
- Gears, belts/pulleys, chain/sprockets, cams/followers
- Shafts, bearings
- Springs, ratchets, clutches, brakes

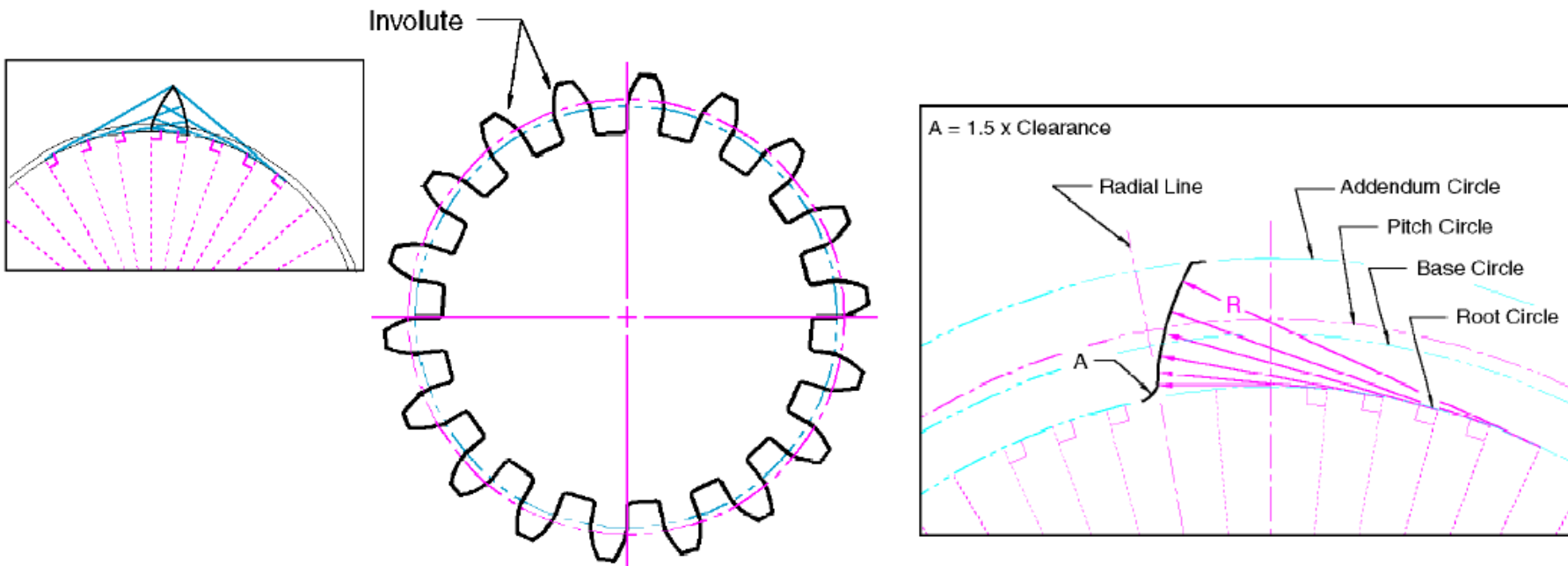
Gears

Gear and pinion mechanisms – power transmission
Between two close-positioned shafts



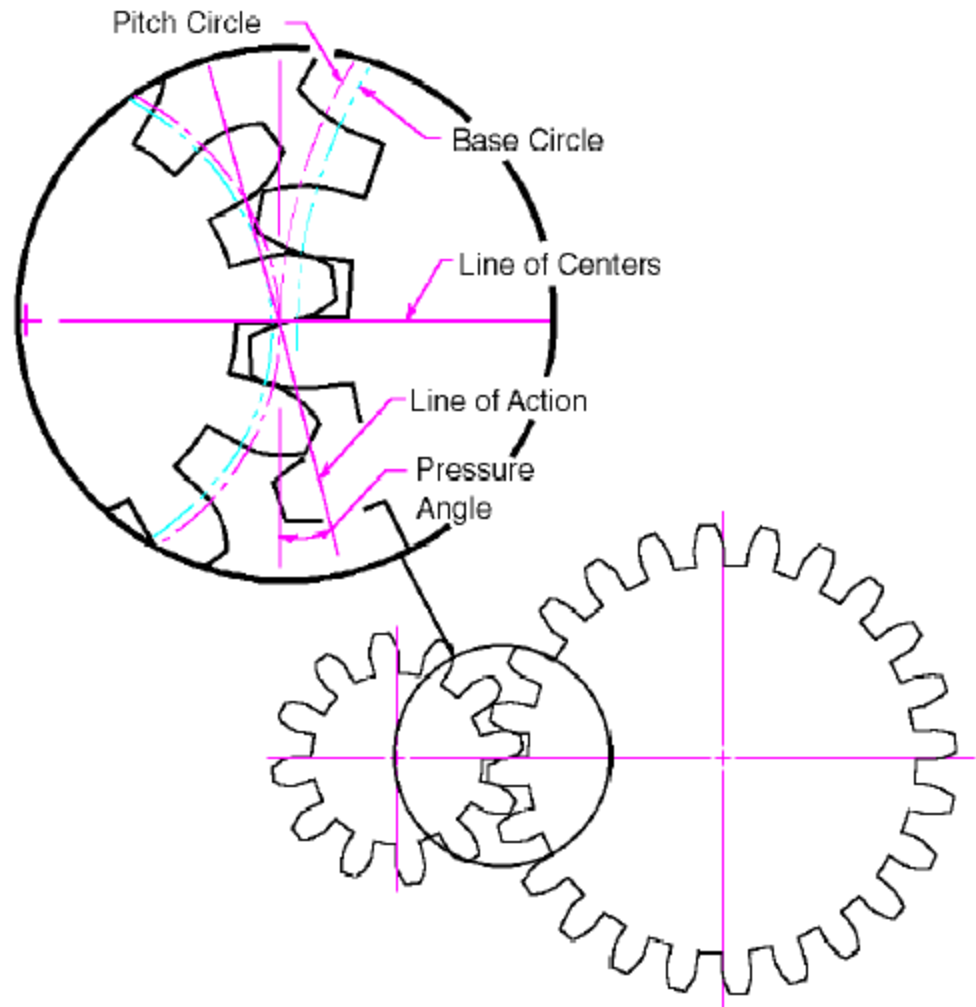
Gears

- The profile of the tooth is a portion of an involute (the curve generated by a line that rolls without sliding on a circle)

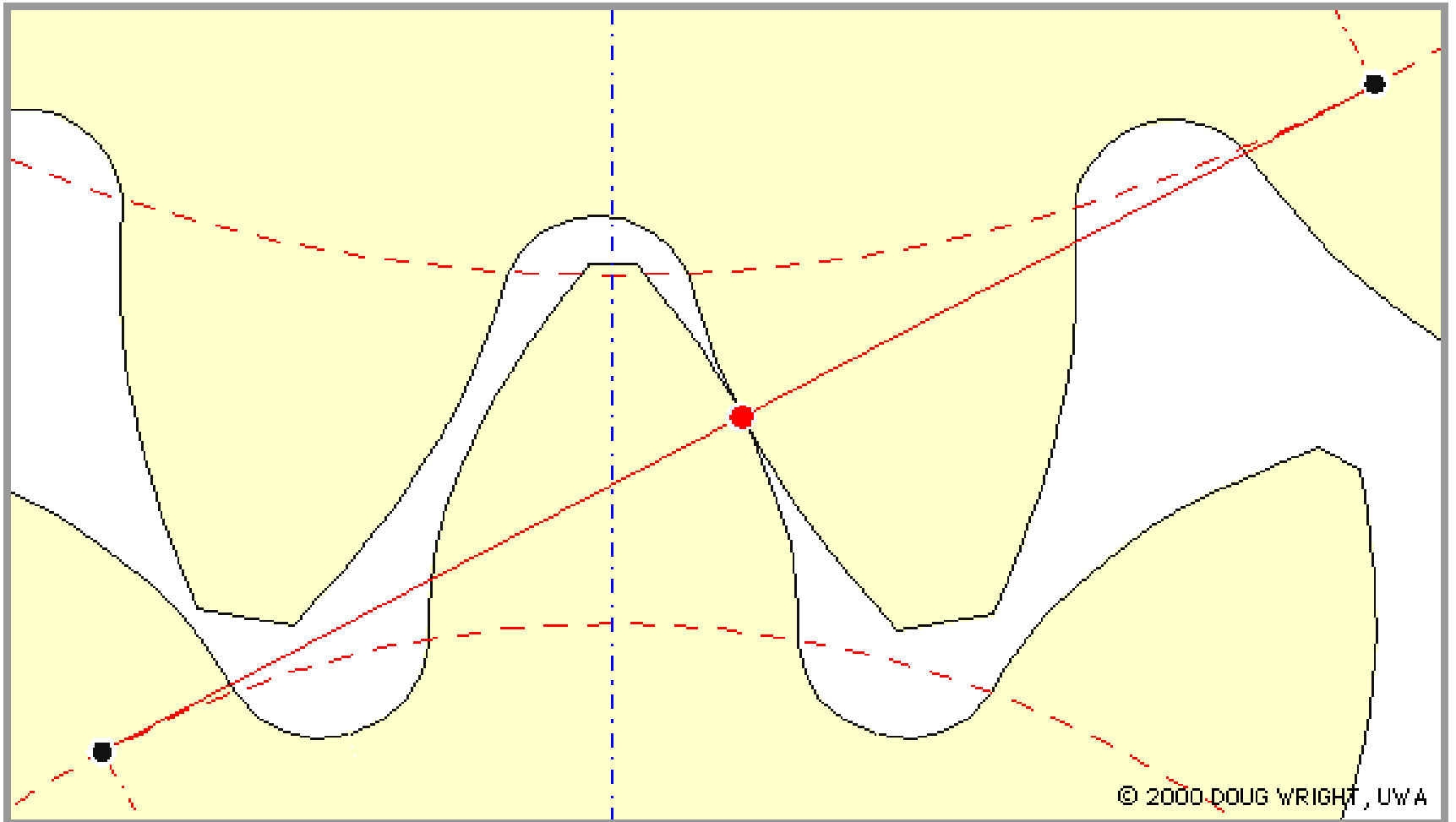


Gears

- Meshing require the same geometry of the teeth
- The rule of meshing – the transmission ratio i

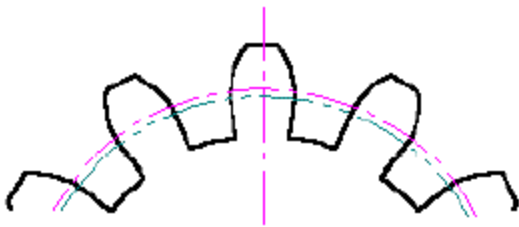


Gears

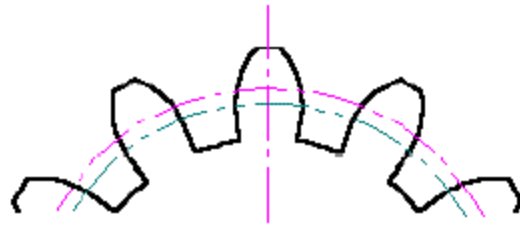


Gears

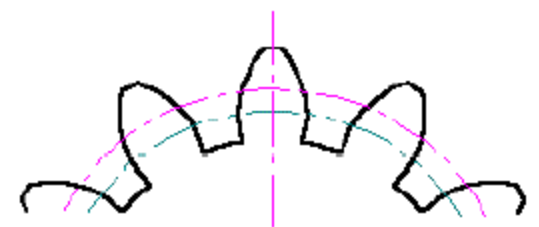
- Pressure angle is the direction of the transmitted force versus the normal to the center line



Pressure Angle
14.5°

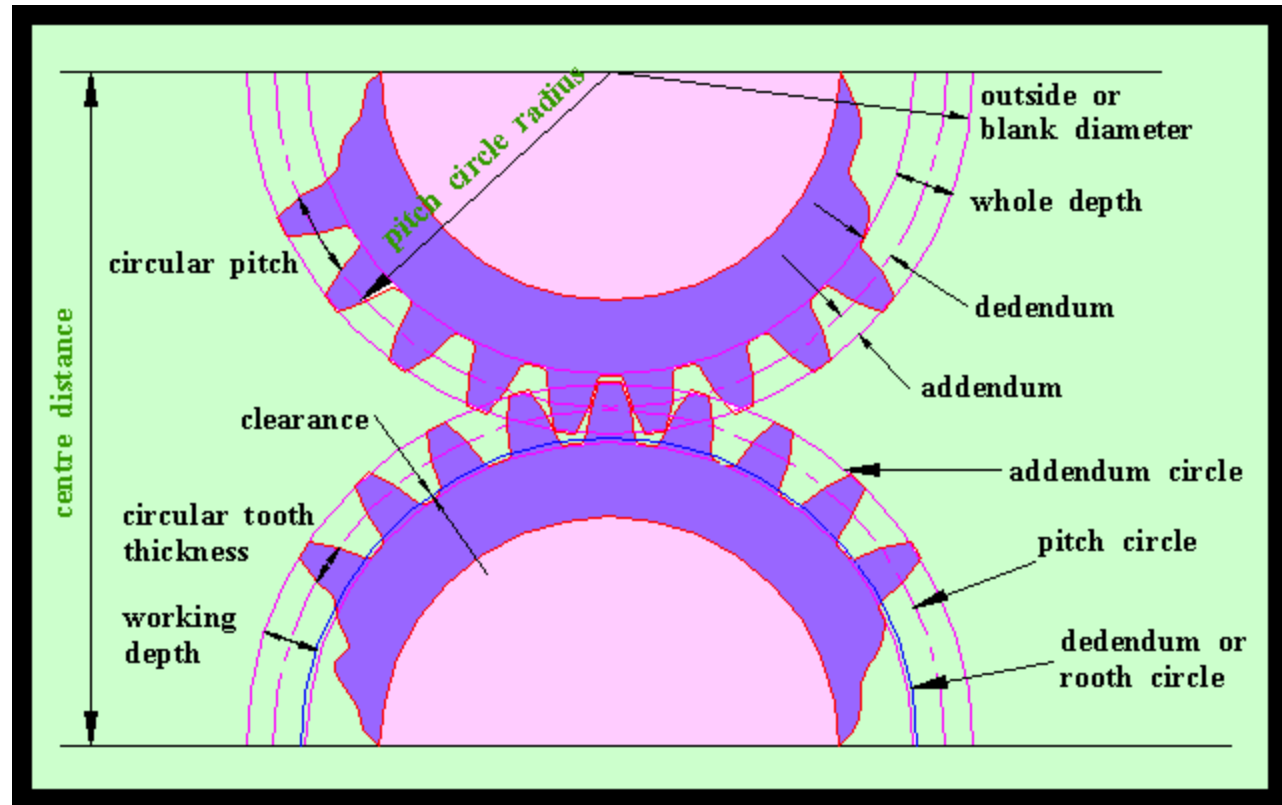
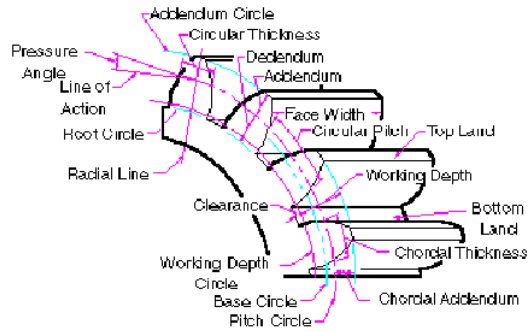


Pressure Angle
20°



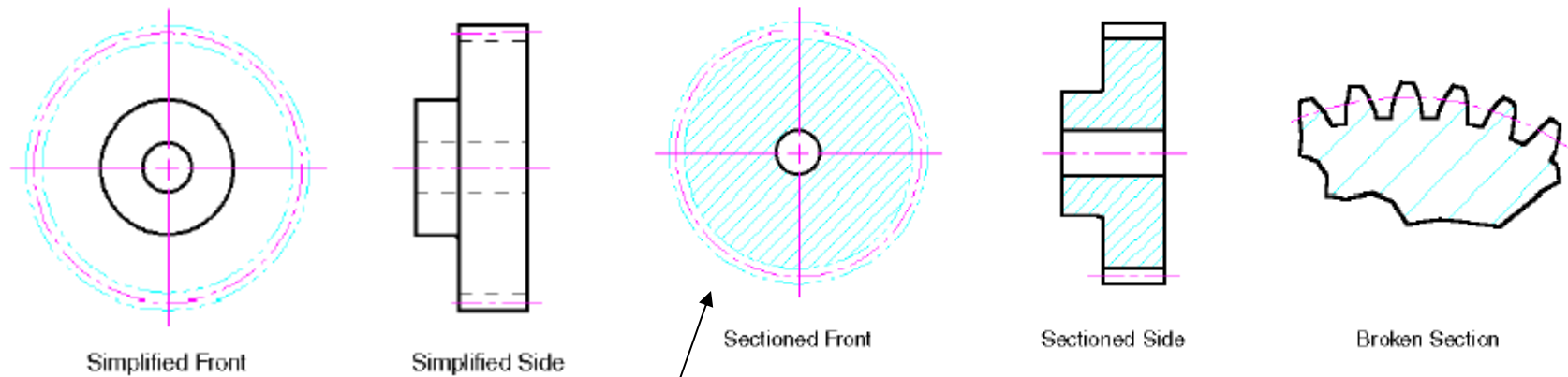
Pressure Angle
25°

Gears nomenclature



Gears representation

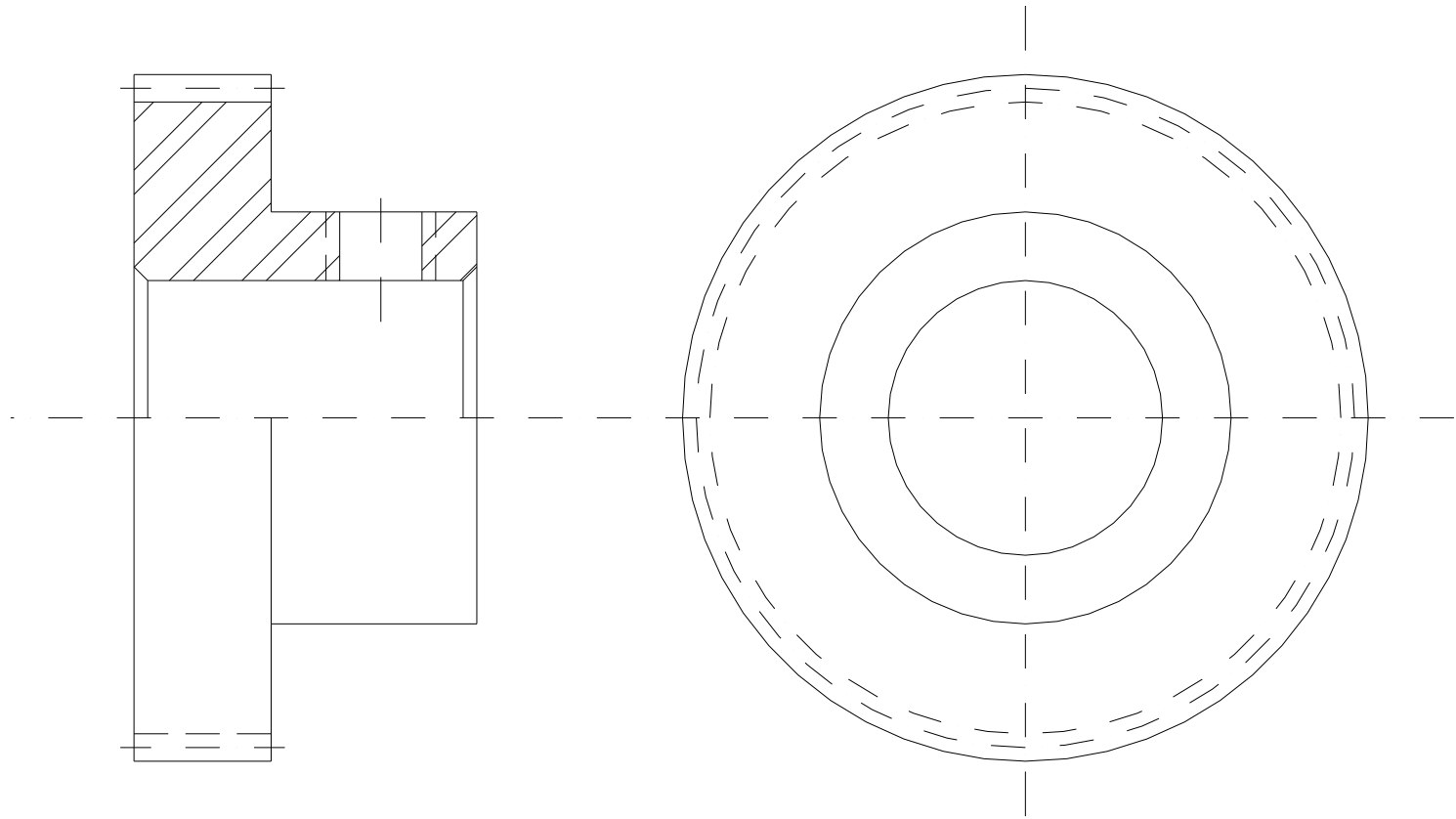
A table containing cutting data must accompany the representation



This gear is not sectioned unless something inside should be shown

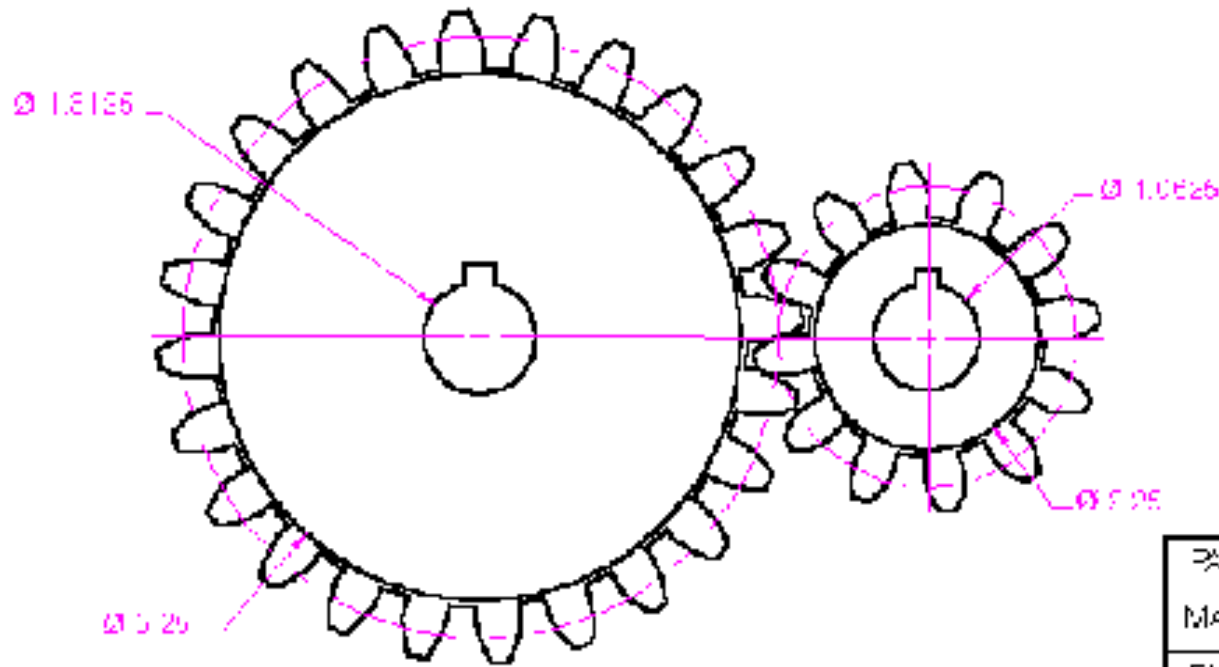
Gears representation

A table containing cutting data must accompany the representation



Gears representation

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

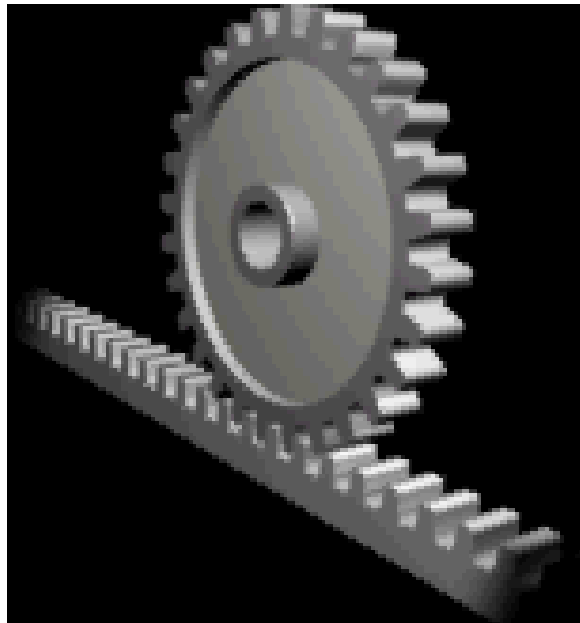


CUTTING DATA	GEAR	PULLEY
NO. OF TEETH	24	12
DIA. PITCH	1	1
TOOTH G-M		
WHOLE DEPTH	.5303	.5303
CHUCKER ADD.	.0010	.0020
PITCH DIA.	3	2
DIFC. THICK	.0025	.0025
WORK DEPTH	.05	.05

	GEAR	PULLEY
PART NUMBER	SS024	SS012
MATERIAL	STEEL	STEEL
FACE WIDTH	3.5	3.5

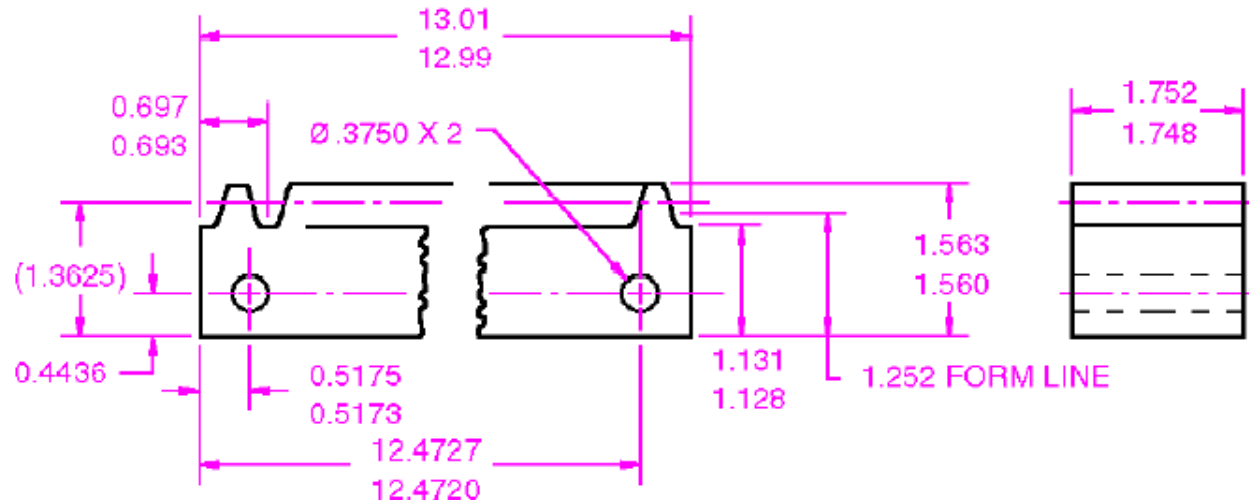
Gears

- Rack representation (the cutting data is included)
- Transmission of linear motion to circular or vice versa

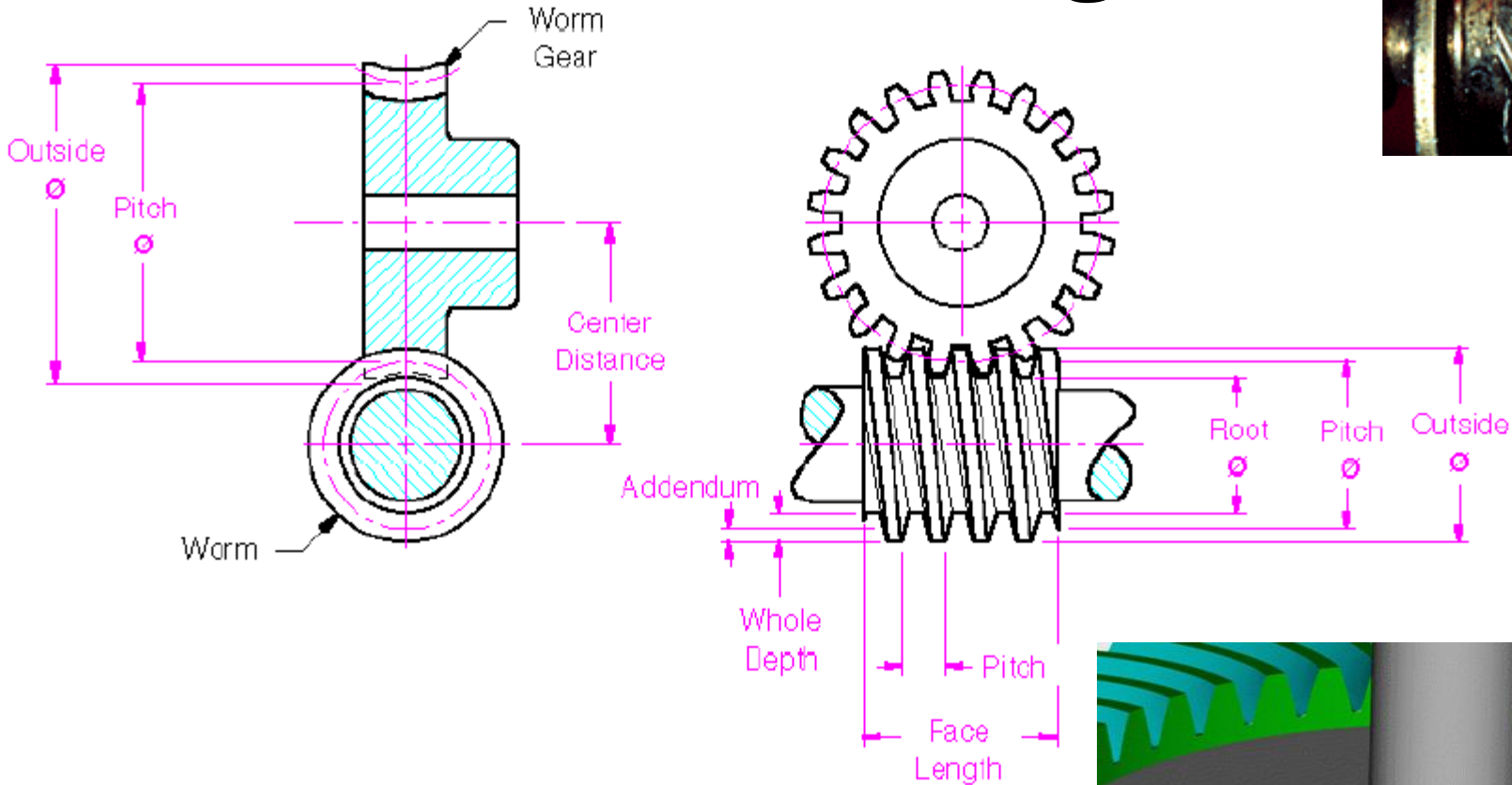


CUTTING DATA	
NUMBER OF TEETH	20
DIAMETRAL PITCH	5
LINEAR PITCH	.6283
PRESSURE ANGLE	14.5°
ACTUAL TOOTH THICK. AT PITCH LINE	.3142
PITCH TOL	.005
INDEX TOL	.005

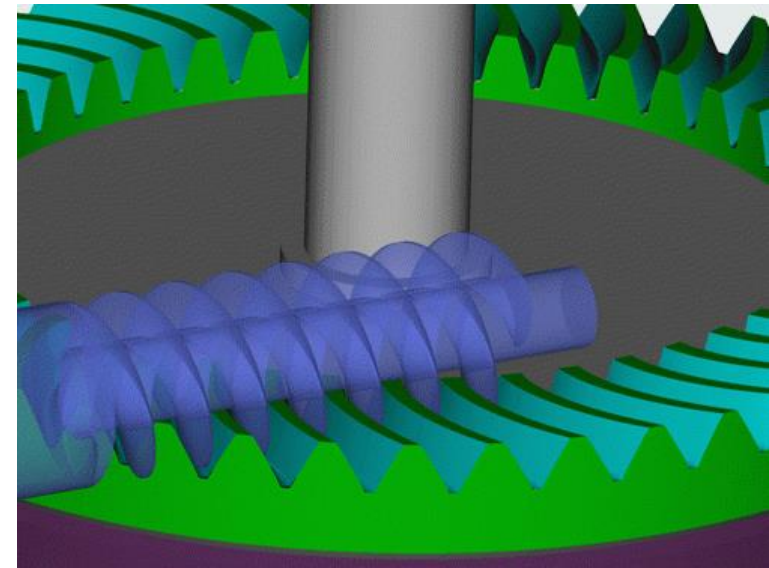
ALL TOOTH ELEMENT SPECIFICATIONS ARE FROM THE SPECIFIED DATUM.



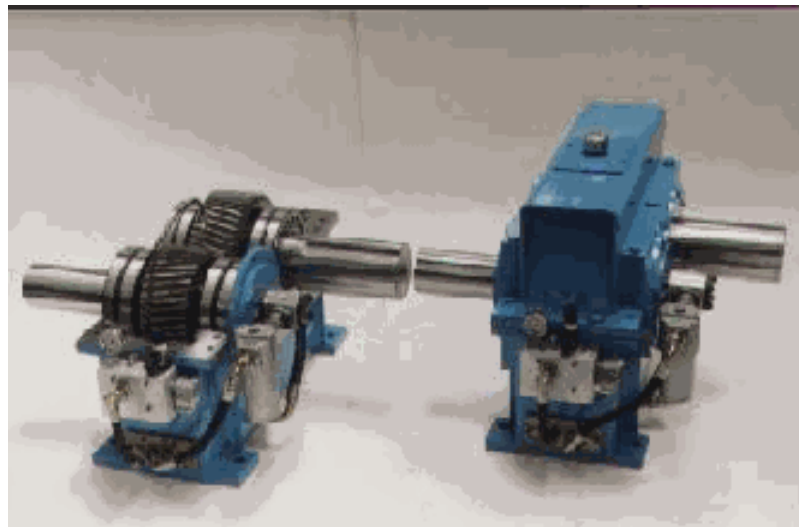
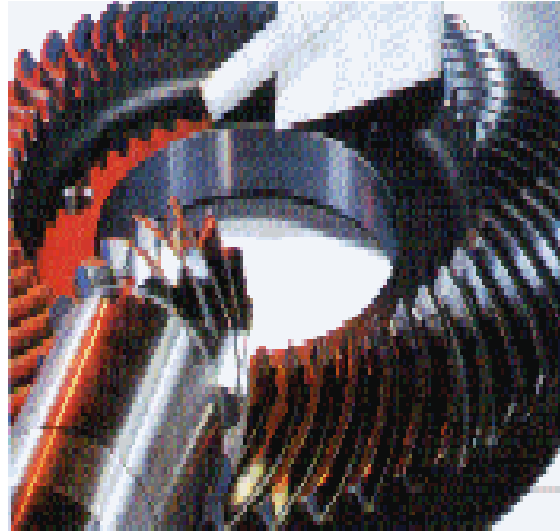
Worm and gear



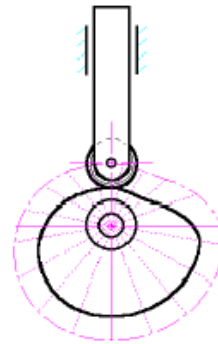
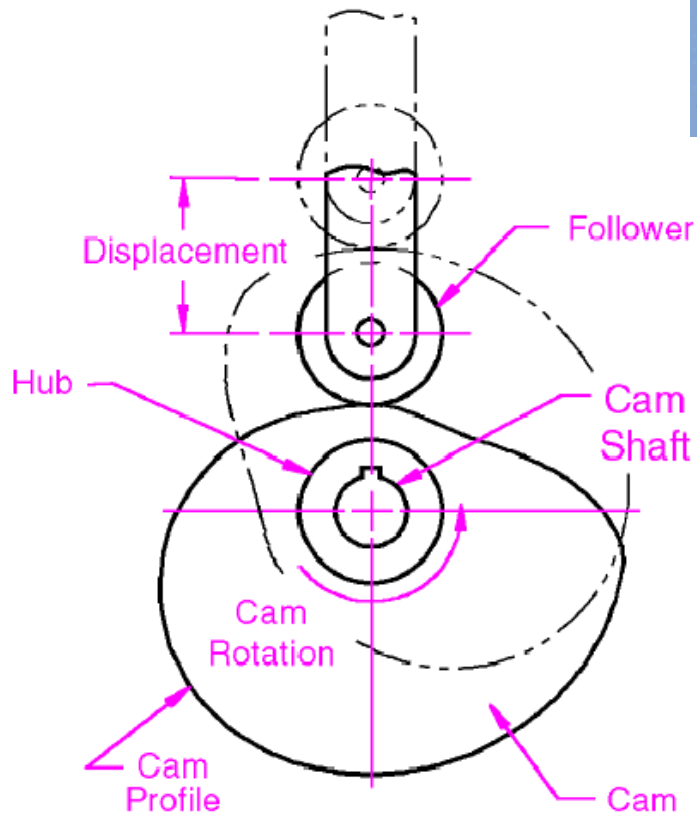
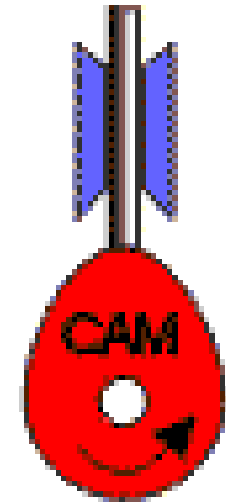
- Worm and Gear representation
- Transmission of motion between **out of plane**, perpendicular axes



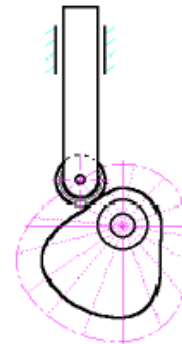
Gears



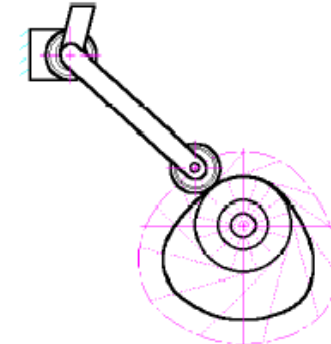
Cams and followers



In-Line

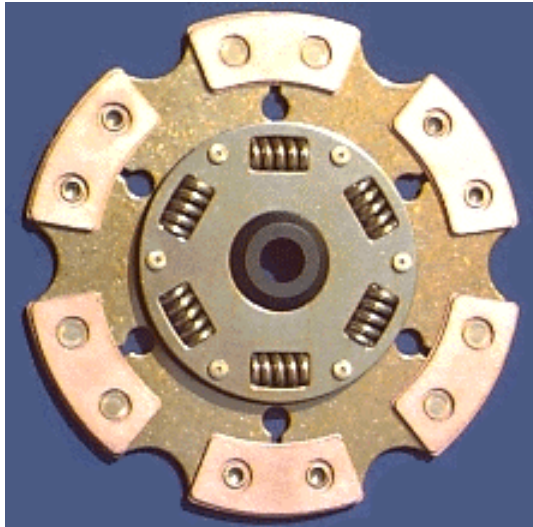
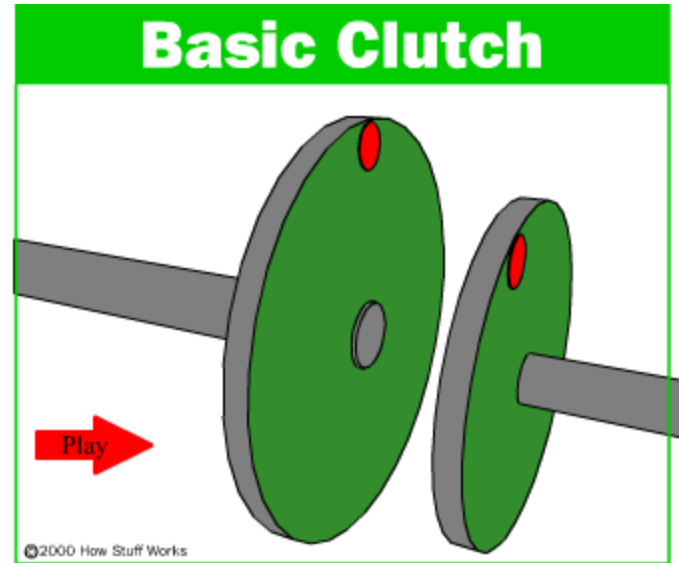


Offset



Pivoted

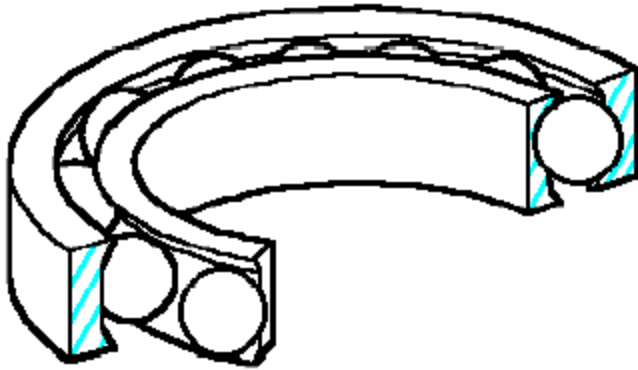
Clutches



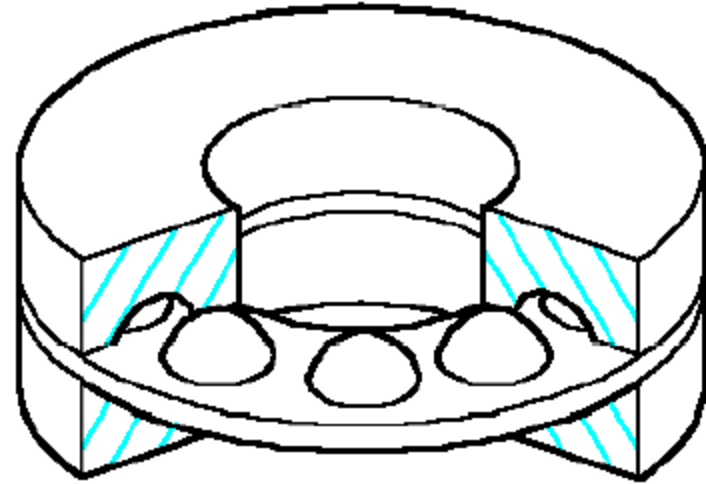
Reduce the high stress when power is coupled to an idle shaft



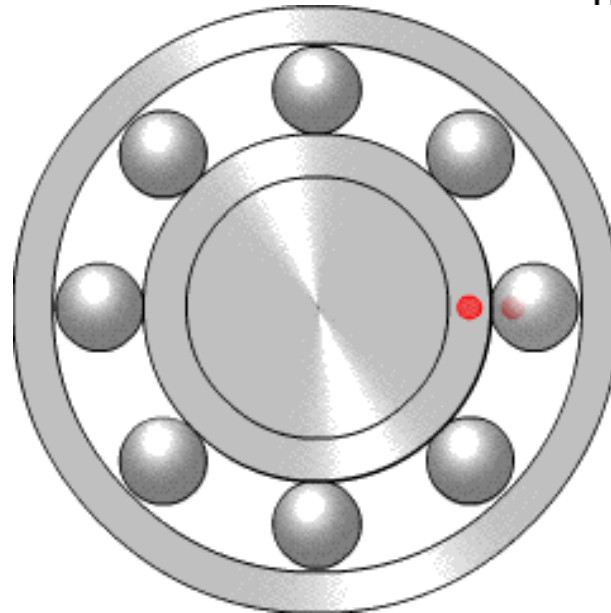
Bearings



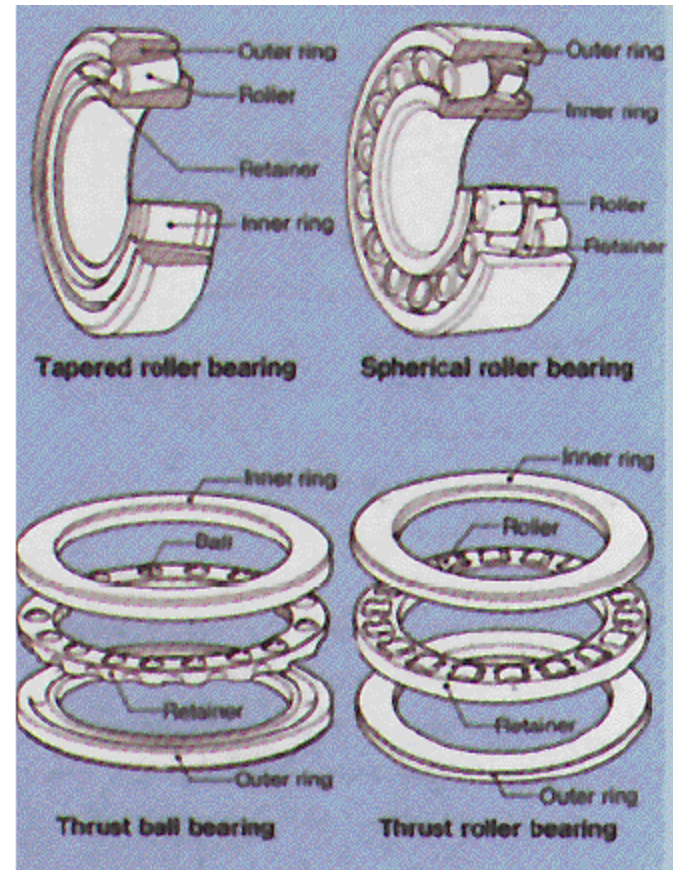
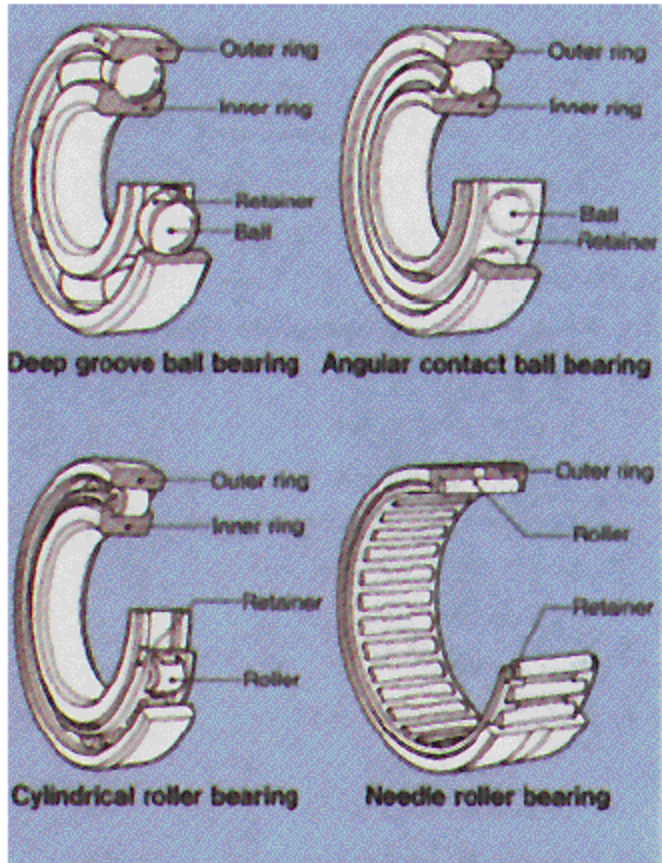
Radial ball bearing



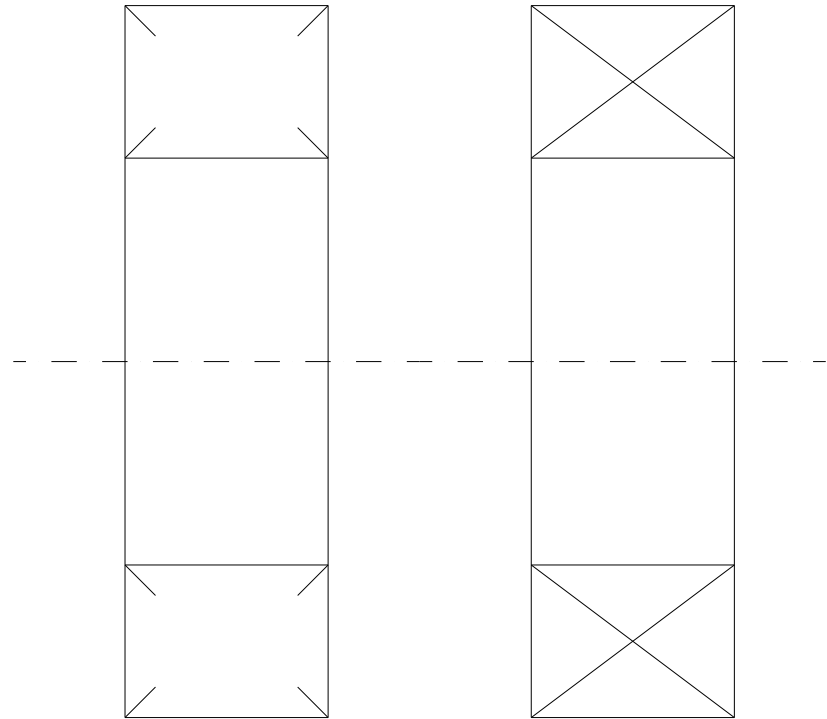
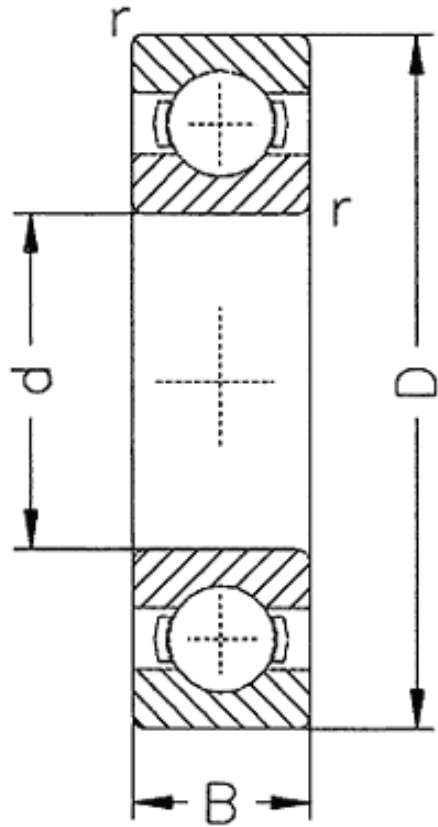
Thrust ball bearing



Ball and roller bearings



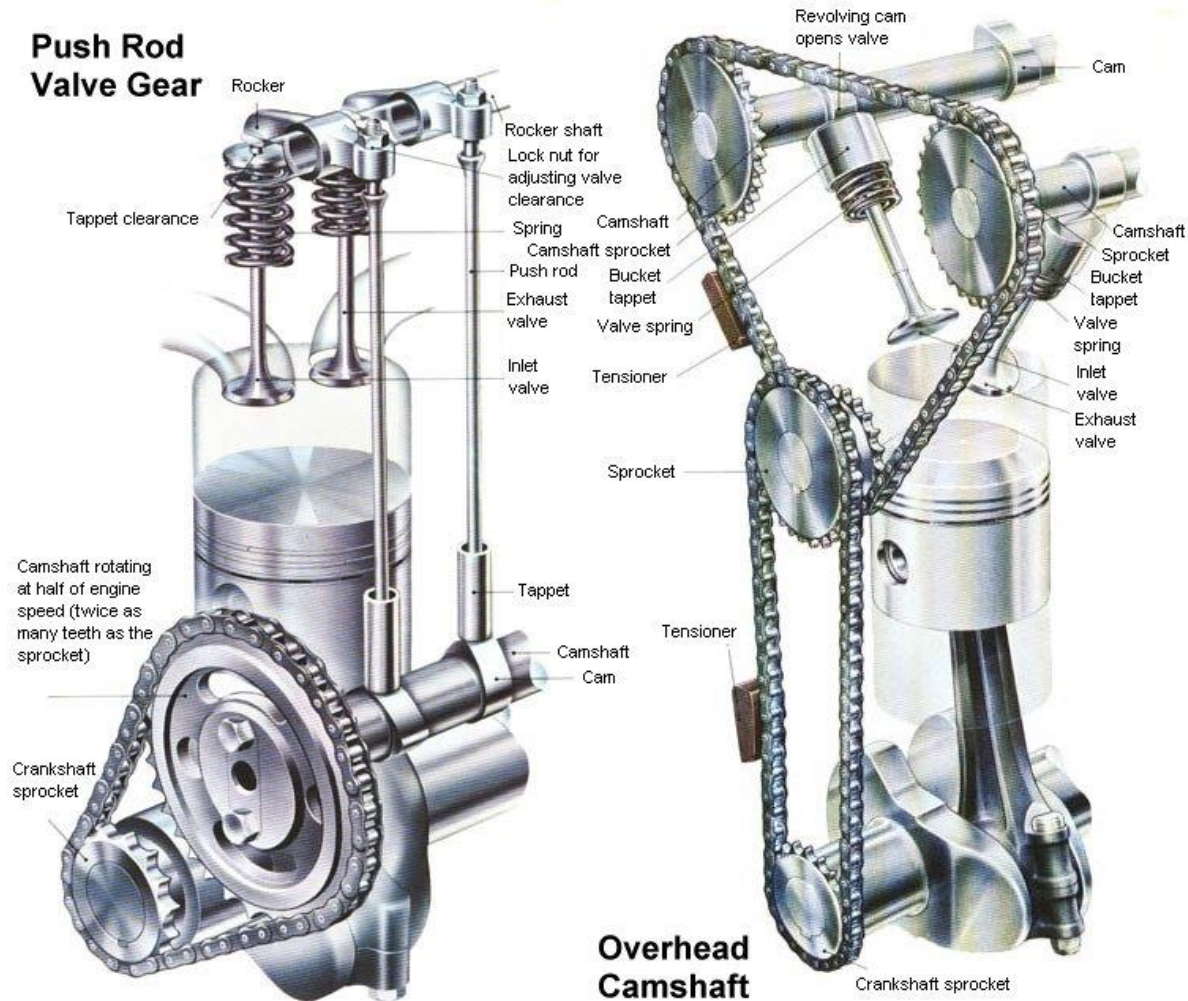
Ball and roller bearings



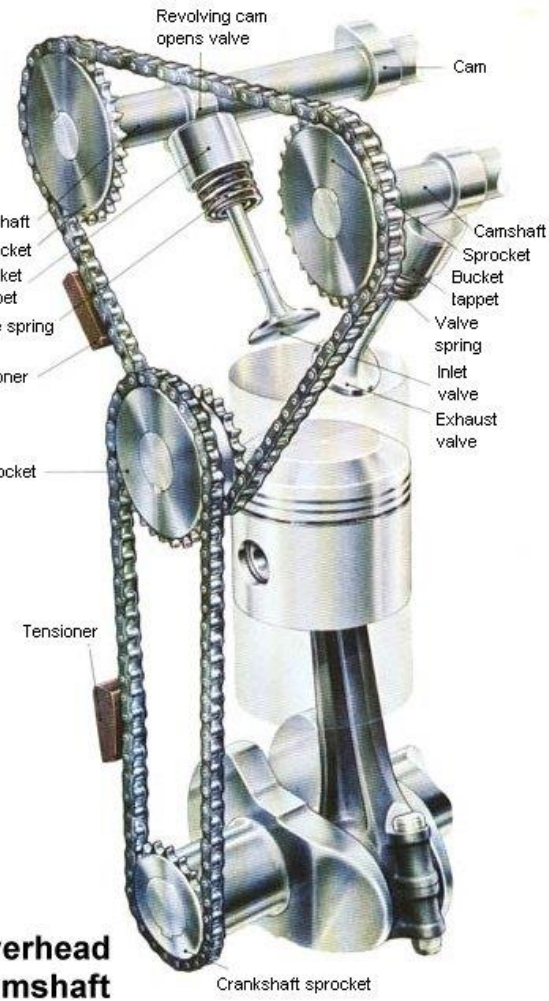
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Example of mechanisms

Push Rod Valve Gear

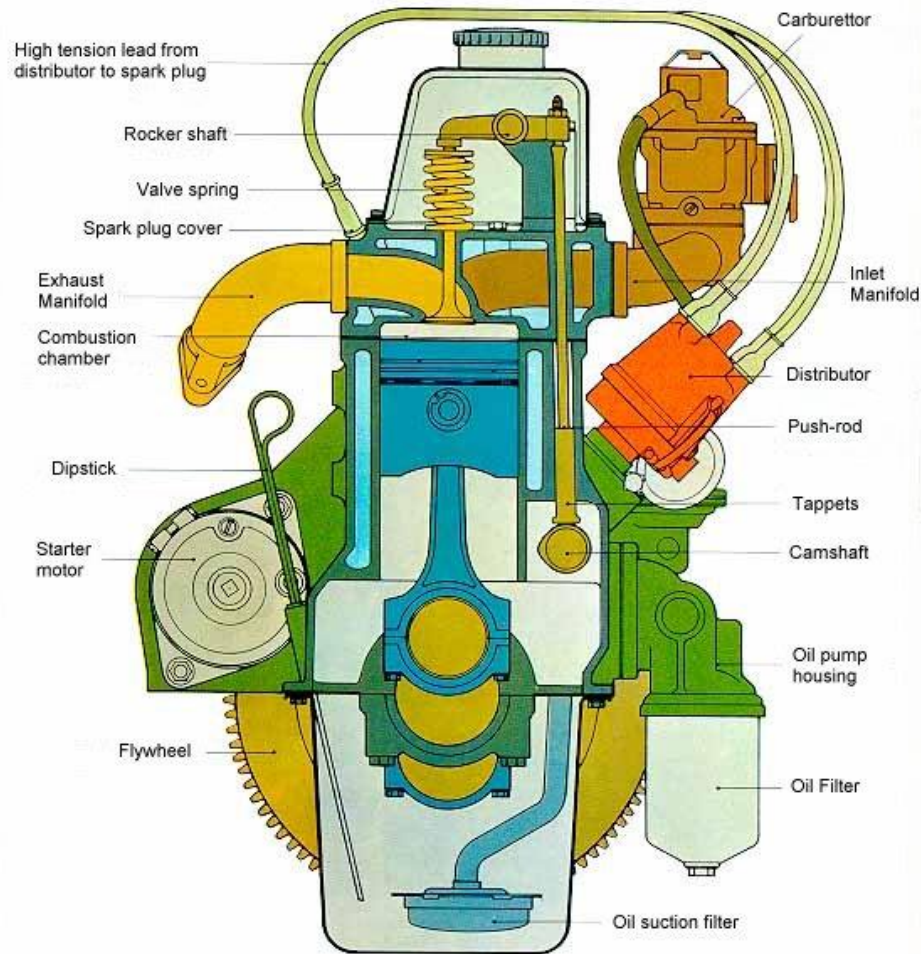


Overhead Camshaft

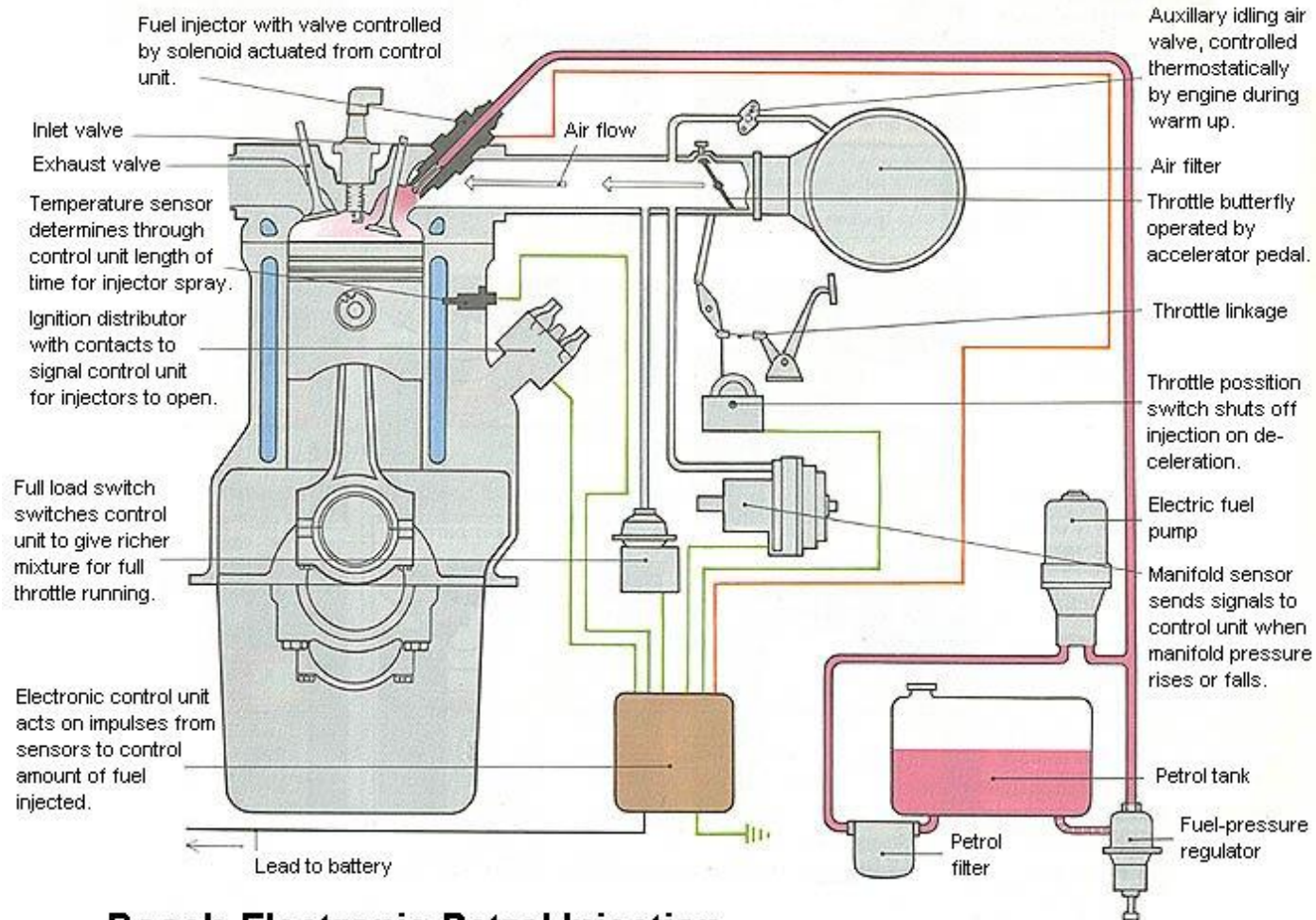


Example of mechanisms

FRONT SECTION OF A 4-CYLINDER INTERNAL COMBUSTION ENGINE

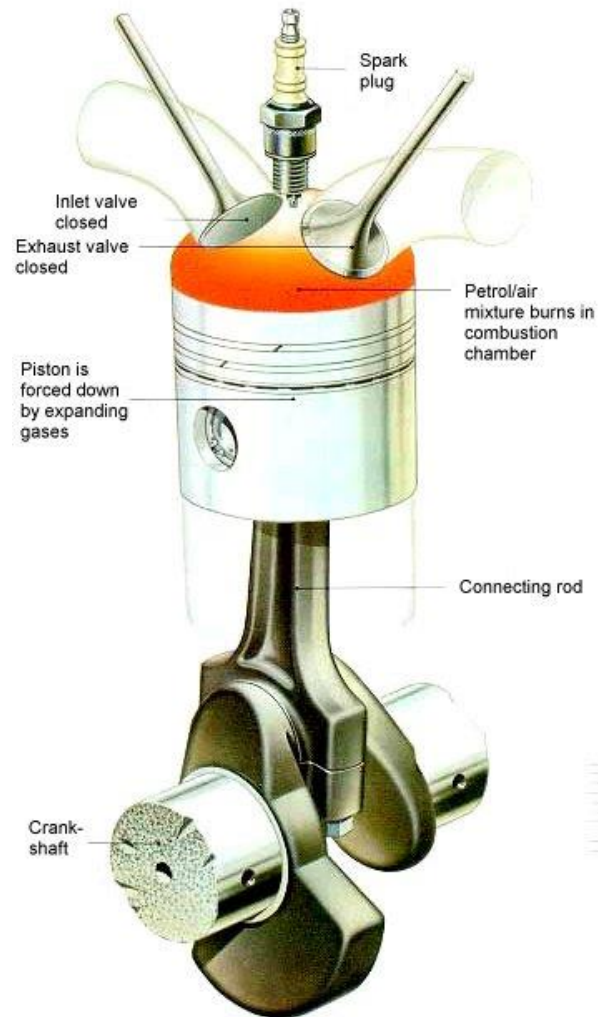


Example of mechanisms

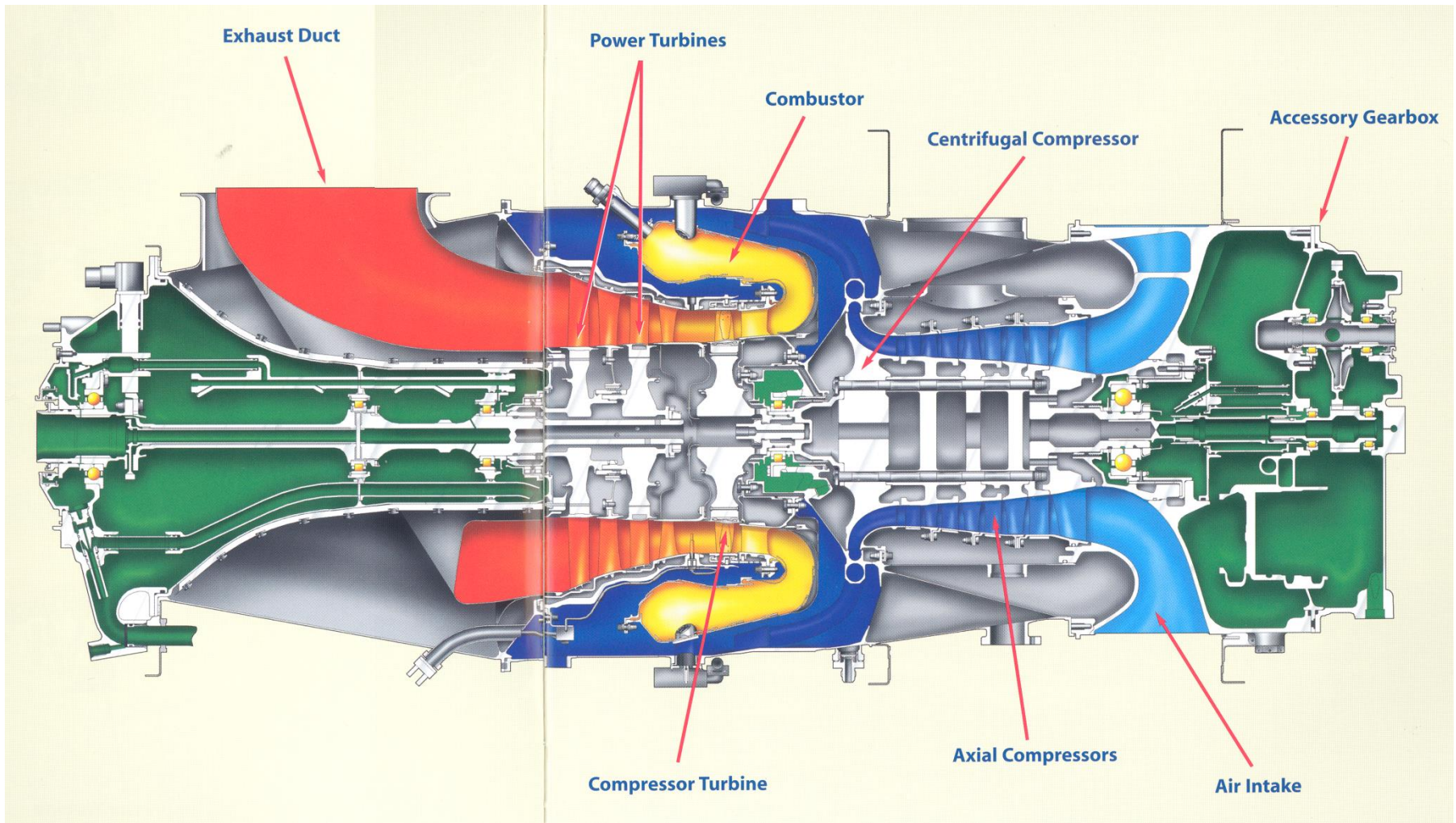


Bosch Electronic Petrol Injection

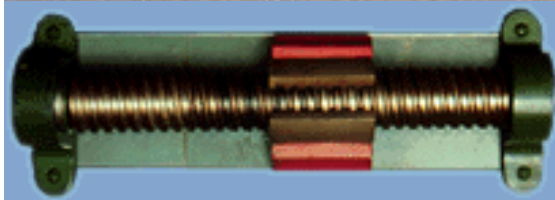
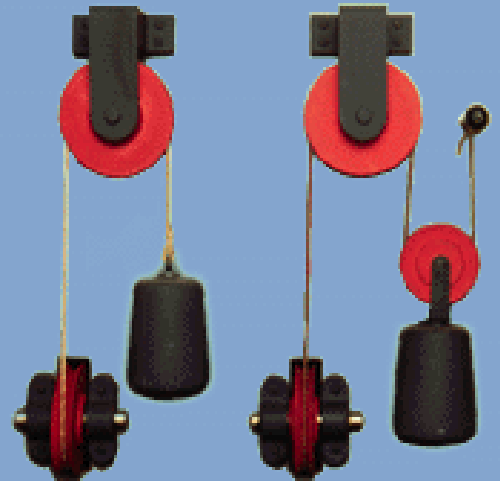
Example of mechanisms



Example of mechanisms



Machine elements

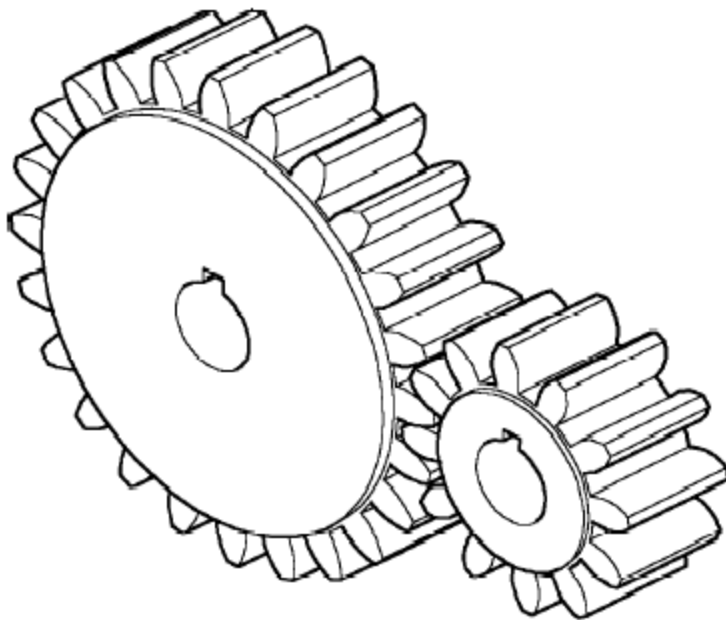


Machine elements

- Used to transmit power or support elements that transmit power
- Gears, belts/pulleys, chain/sprockets, cams/followers
- Shafts, bearings
- Springs, ratchets, clutches, brakes

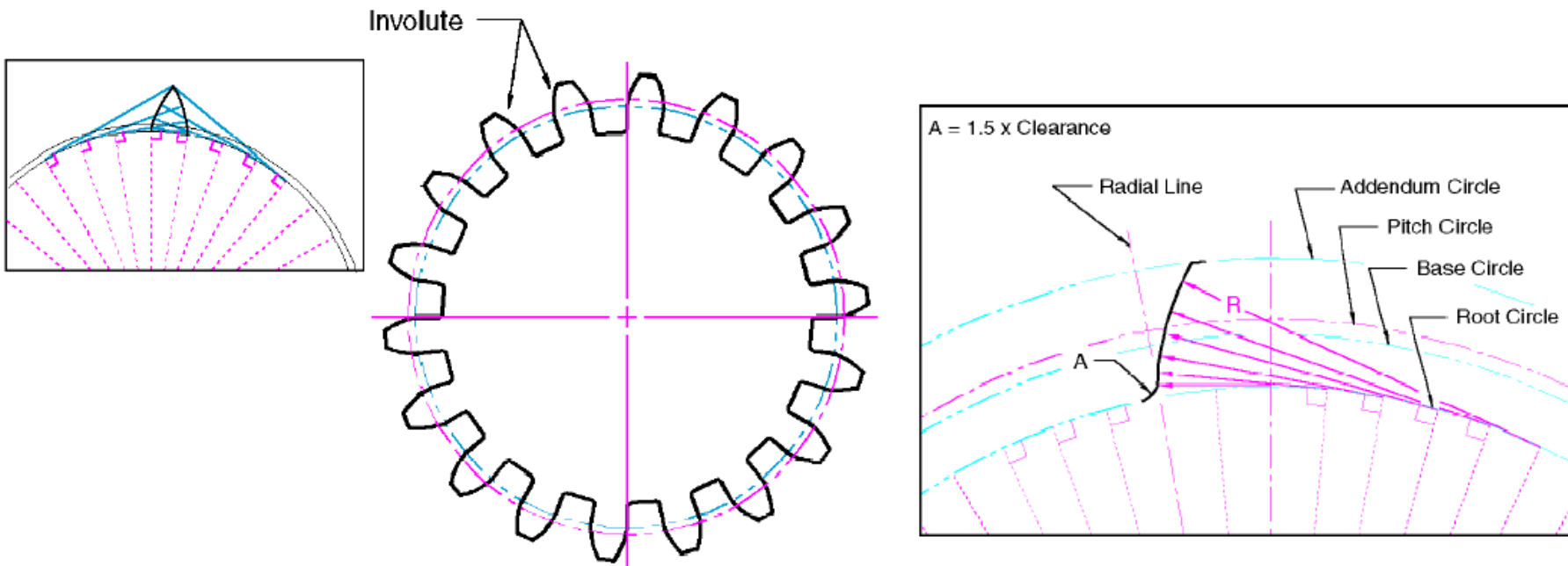
Gears

Gear and pinion mechanisms – power transmission
Between two close-positioned shafts



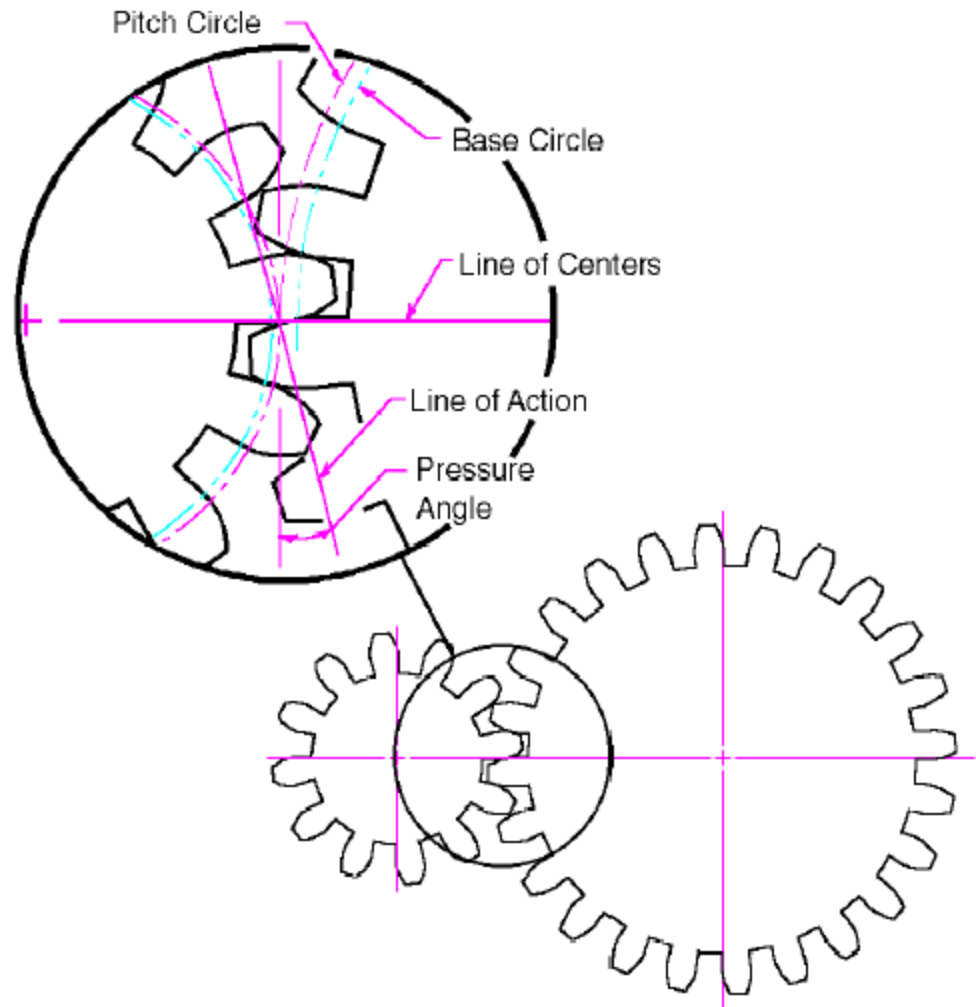
Gears

- The profile of the tooth is a portion of an involute (the curve generated by a line that rolls without sliding on a circle)



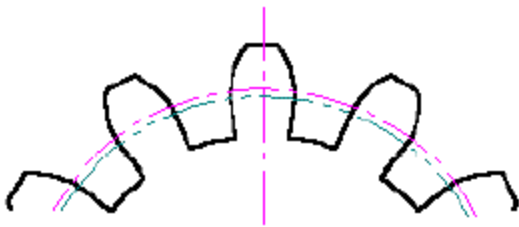
Gears

- Meshing require the same geometry of the teeth
- The rule of meshing – the transmission ratio i

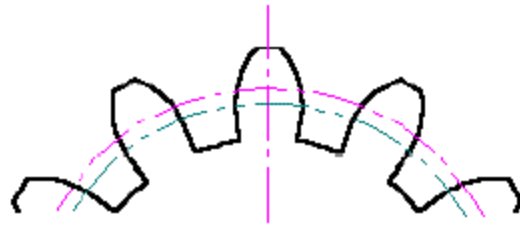


Gears

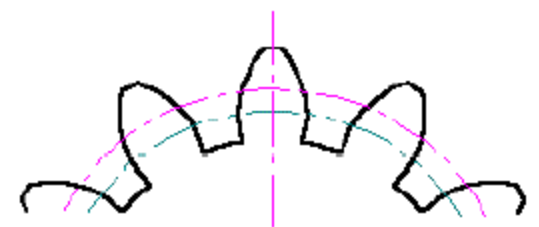
- Pressure angle is the direction of the transmitted force versus the normal to the center line



Pressure Angle
14.5°

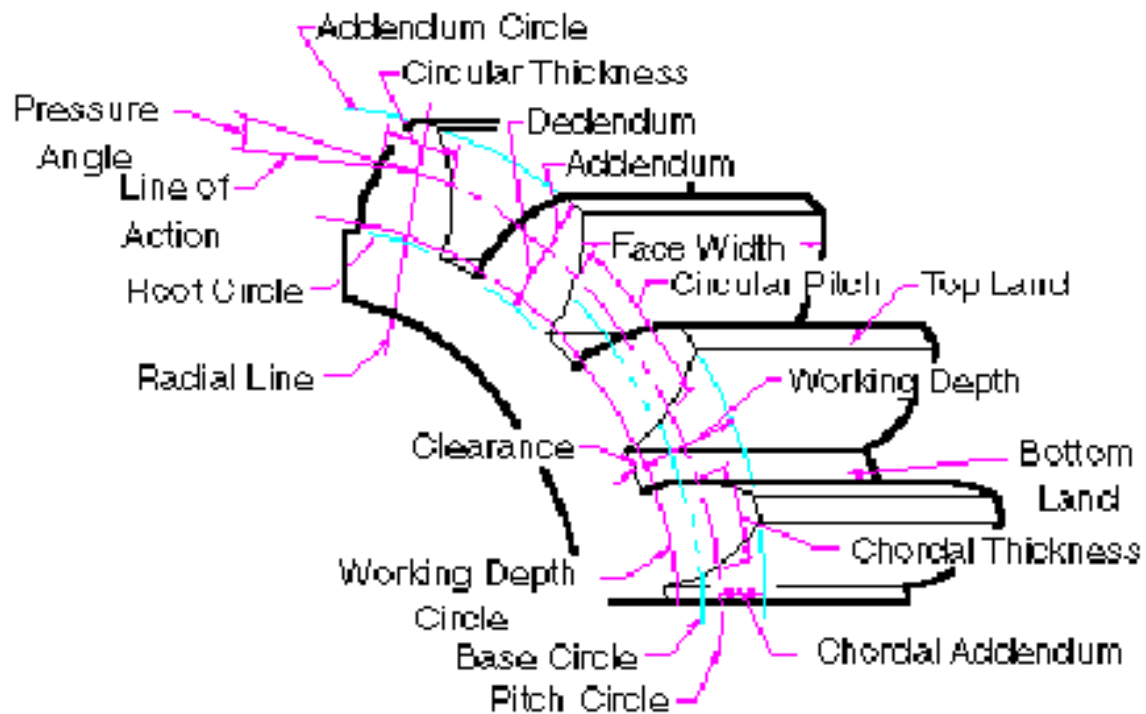


Pressure Angle
20°



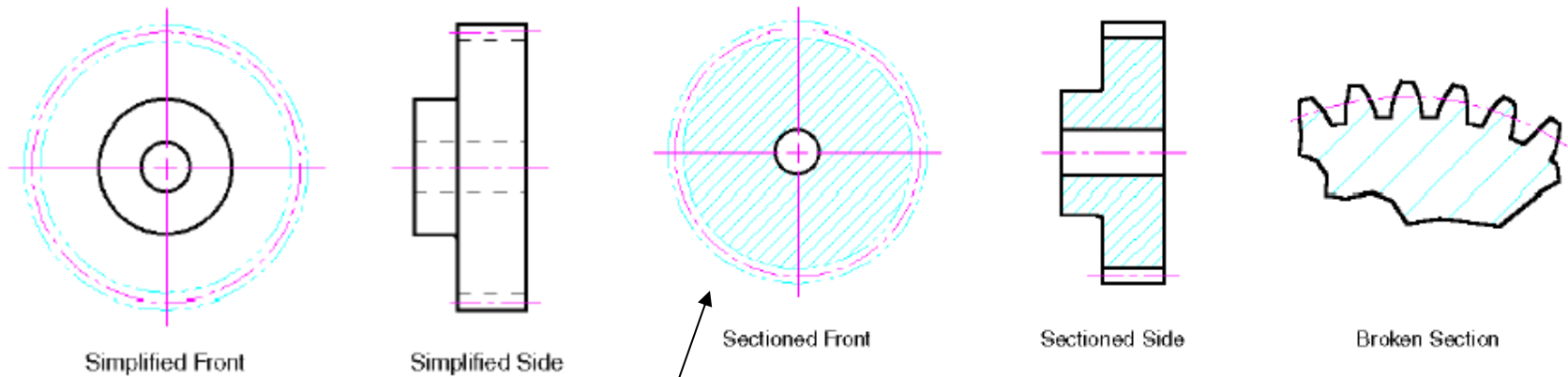
Pressure Angle
25°

Gears nomenclature



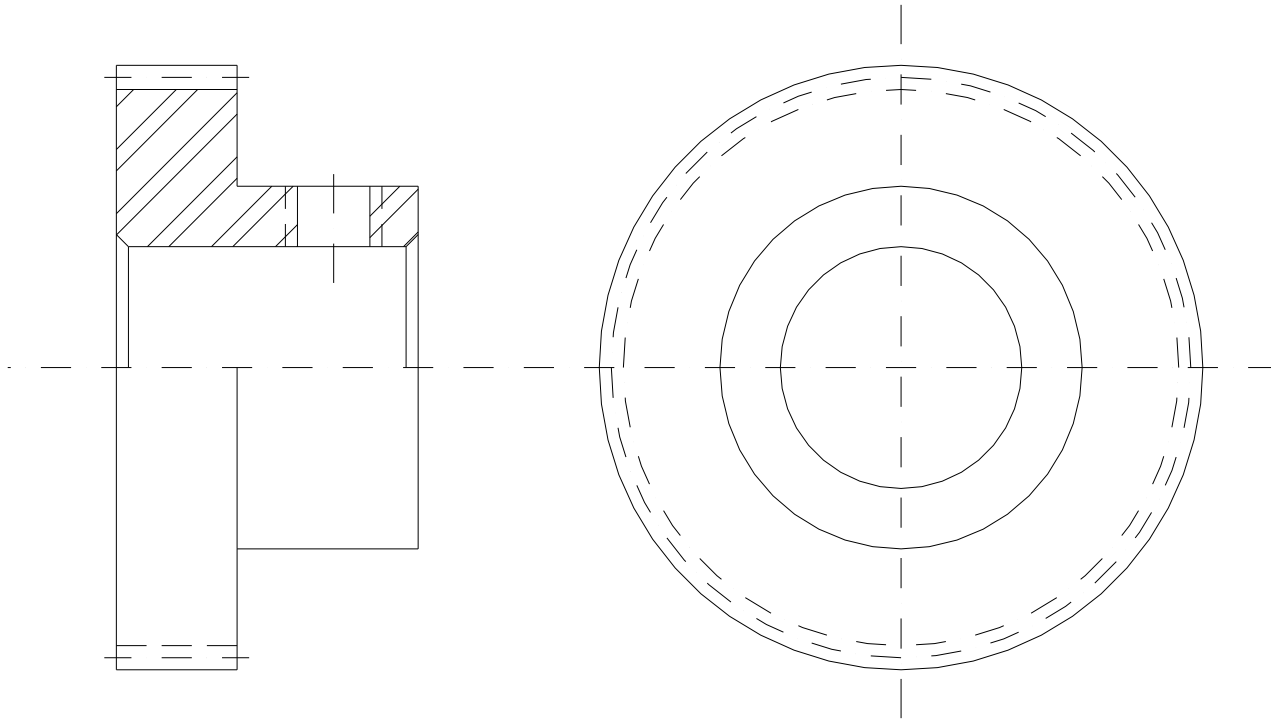
Gears representation

A table containing cutting data must accompany the representation



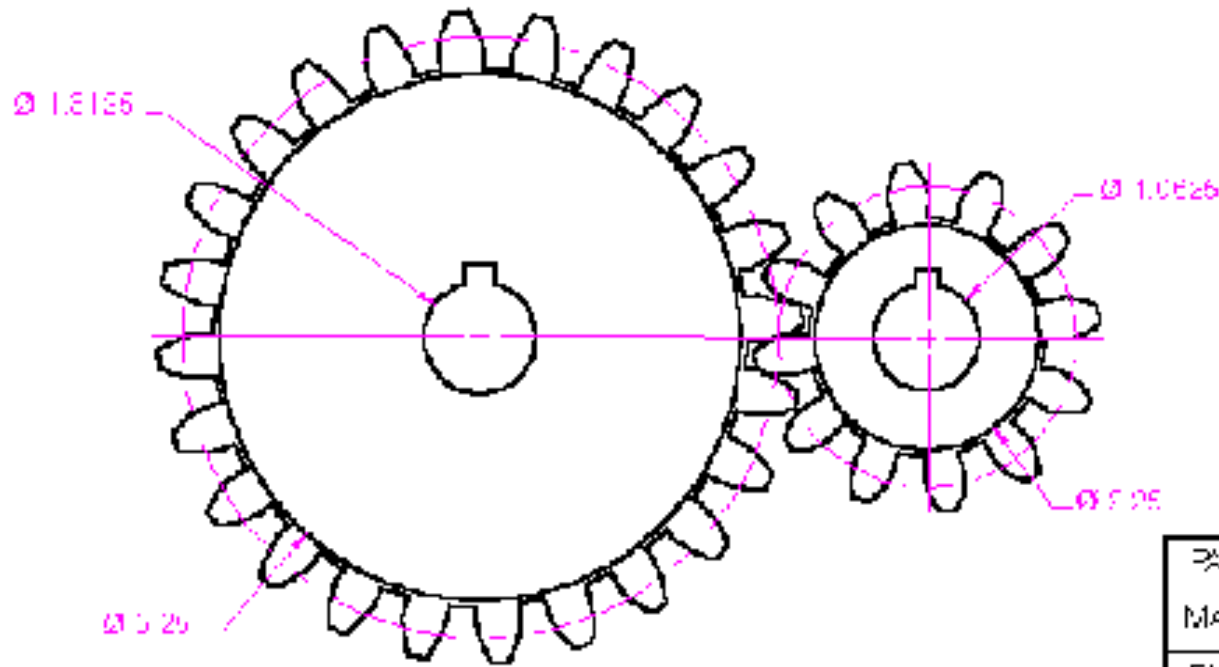
This gear is not sectioned unless something inside should be shown

Gears representation



Gears representation

NOTE KEYWAY FOR GEAR 5/16 X 5/32
KEYWAY FOR P NION 1/4 X 1/8



CUTTING DATA	GEAR	P NION
NO OF TEETH	24	12
DIA. PITCH	1	1
TOOTH G-M		
WHDLE DEPTH	.5303	.5303
CHUCKL ADD.	.0010	.0020
PITCH DIA	3	3
DIFC. THICK	.0025	.0025
WORK DEPTH	.05	.05

	GEAR	P NION
PART NUMBER	SS024	SS012
MATERIAL	STEEL	STEEL
FACE WIDTH	3.5	3.5

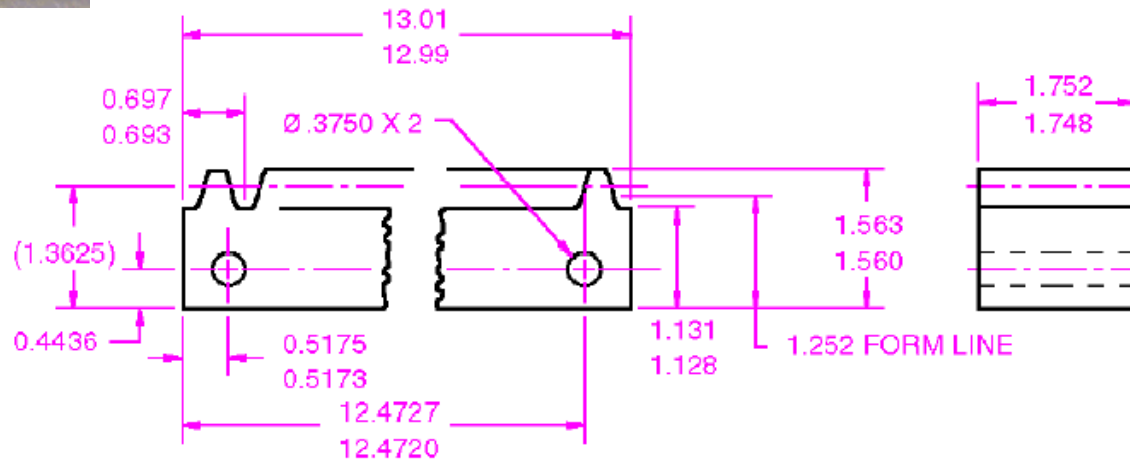
Gears

- Rack representation (the cutting data is included)

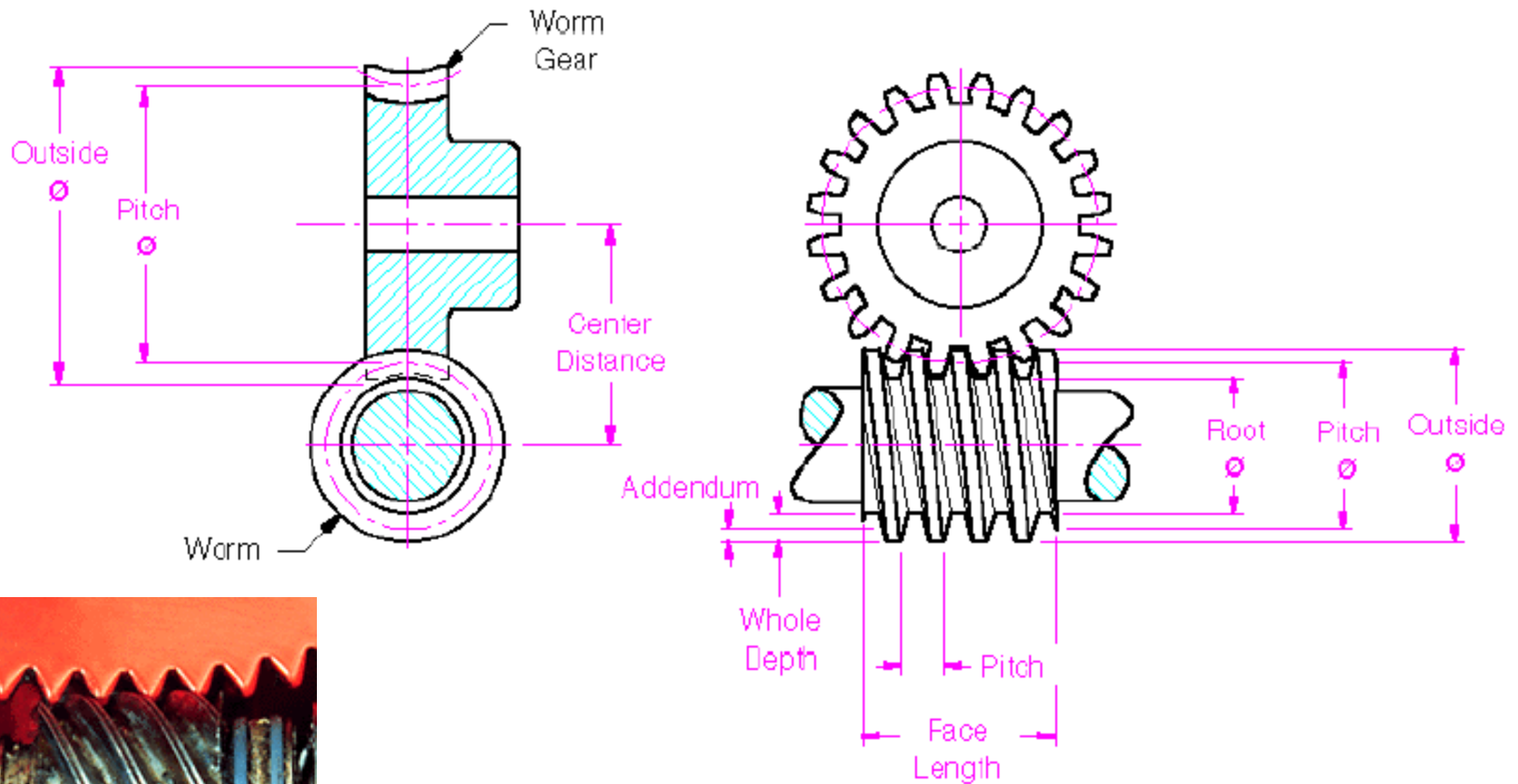


ALL TOOTH ELEMENT SPECIFICATIONS ARE FROM THE SPECIFIED DATUM.

CUTTING DATA	
NUMBER OF TEETH	20
DIAMETRAL PITCH	5
LINEAR PITCH	.6283
PRESSURE ANGLE	14.5°
ACTUAL TOOTH THICK. AT PITCH LINE	.3142
PITCH TOL	.005
INDEX TOL	.005

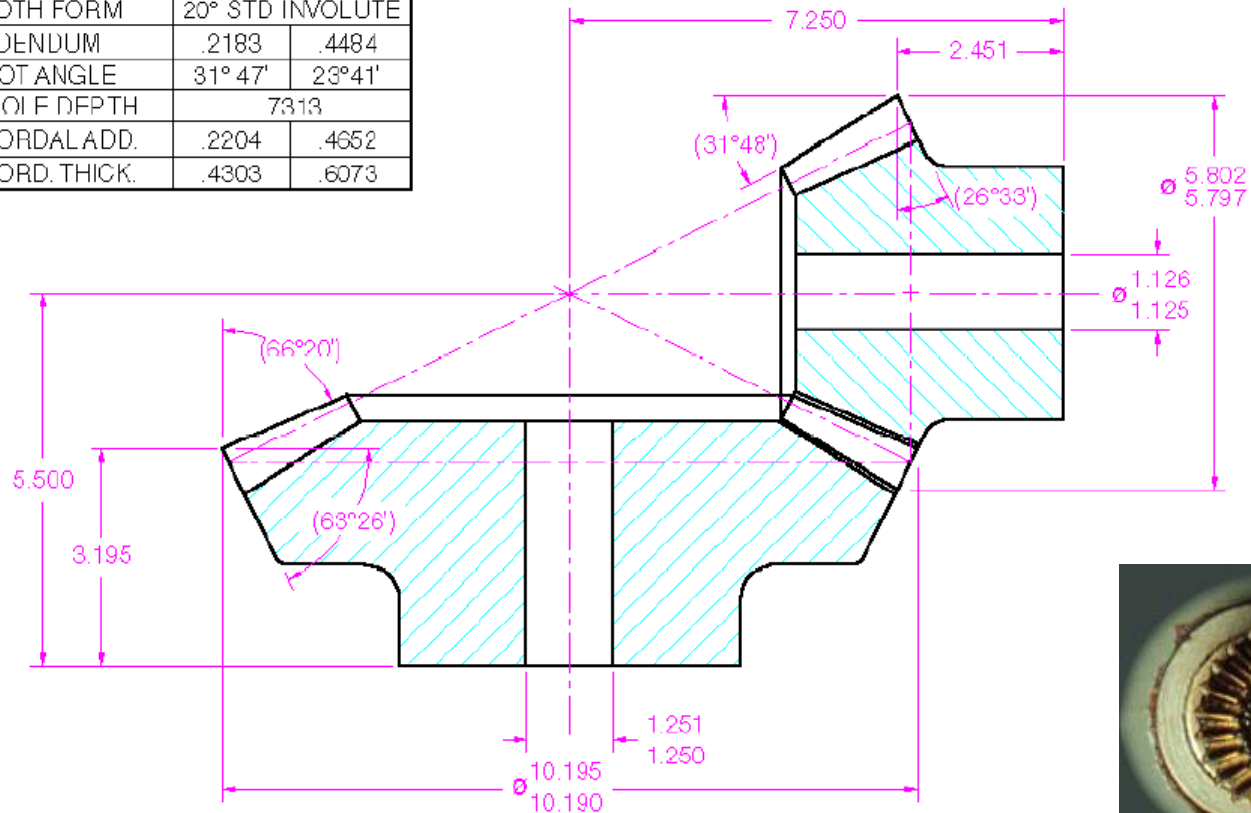


Worm and gear

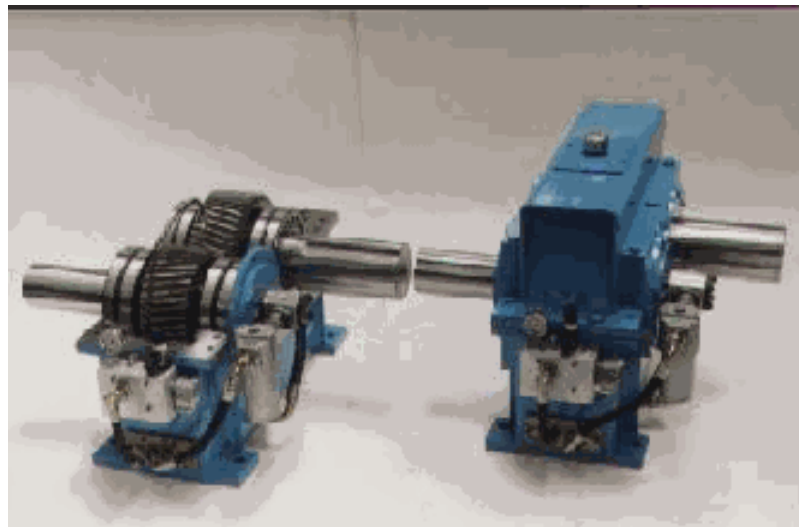
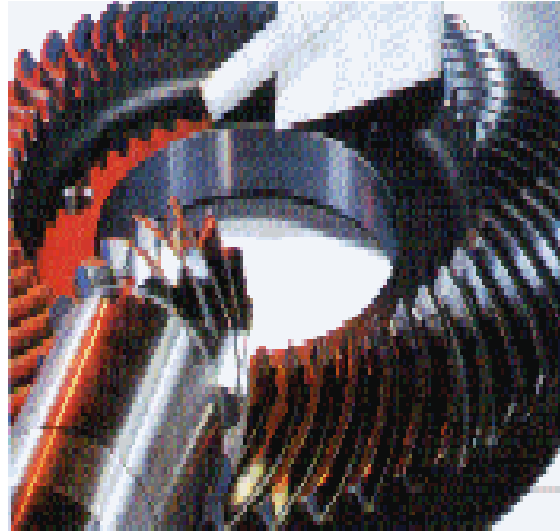


Bevel gear assembly

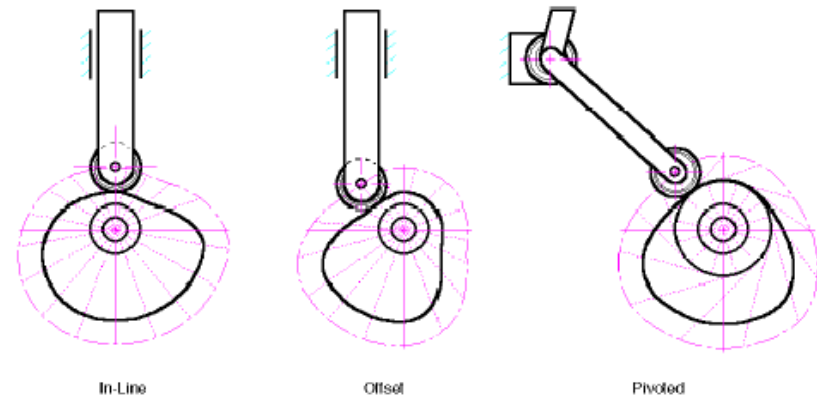
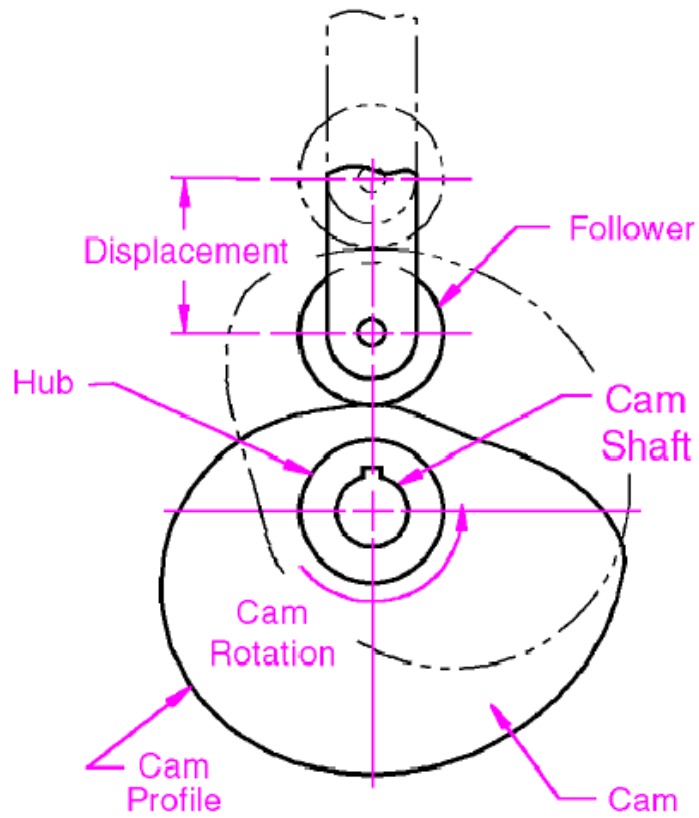
CUTTING DATA		
	GEAR	PINION
NO. OF TEETH	30	15
DIA. PITCH	3	
TOOTH FORM	20° STD INVOLUTE	
ADDENDUM	.2183	.4484
ROOT ANGLE	31° 47'	23° 41'
WHOLE DEPTH	.7313	
CHORDAL ADD.	.2204	.4652
CHORD. THICK.	.4303	.6073



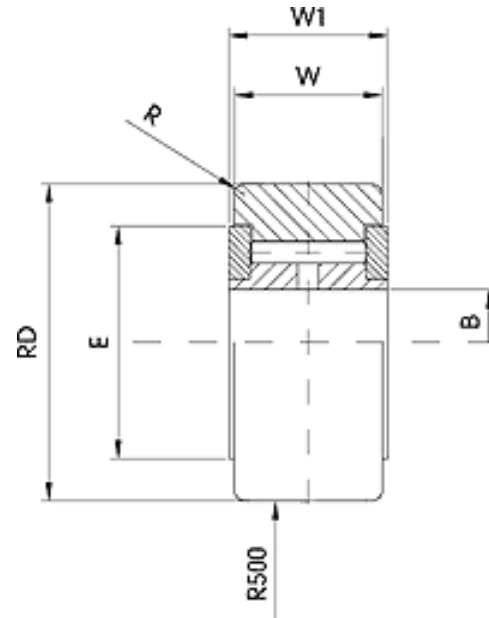
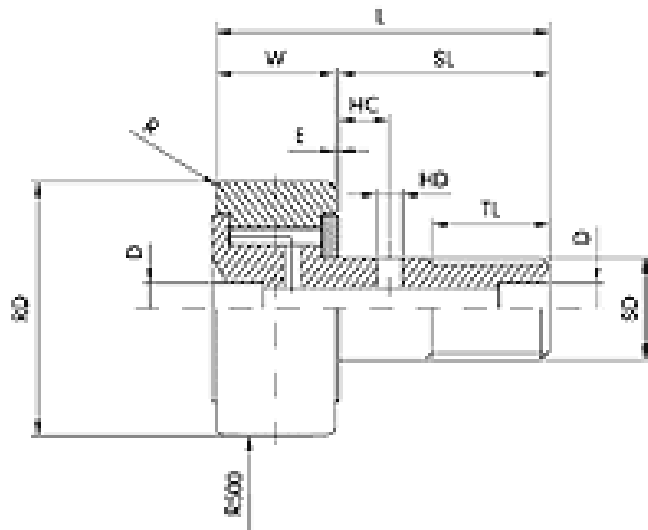
Gears



Cams and followers



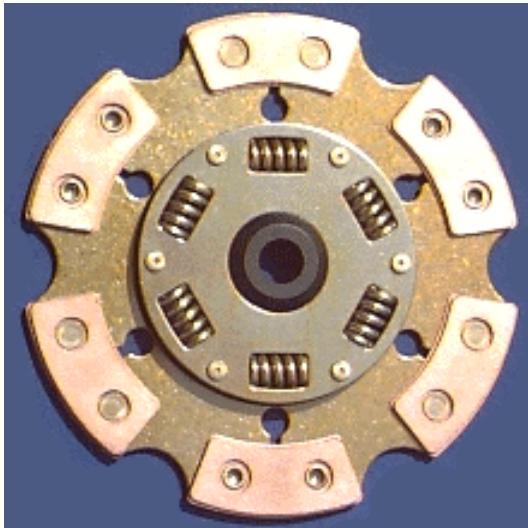
Cams



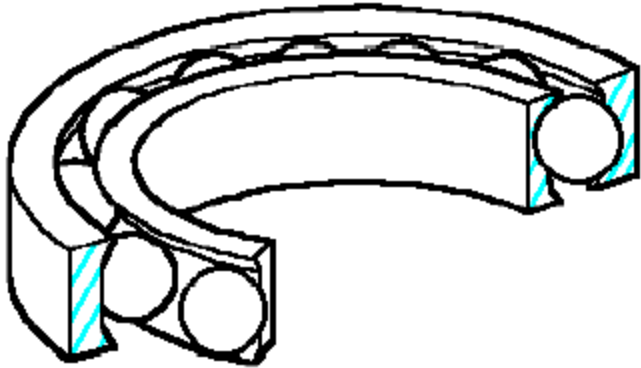
Roller-type followers stud and bore

Clutches

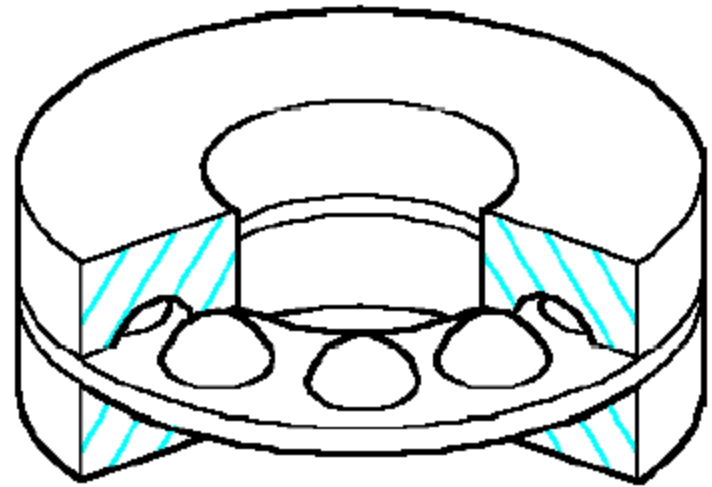
Reduce the high stress when power is coupled to an idle shaft



Bearings

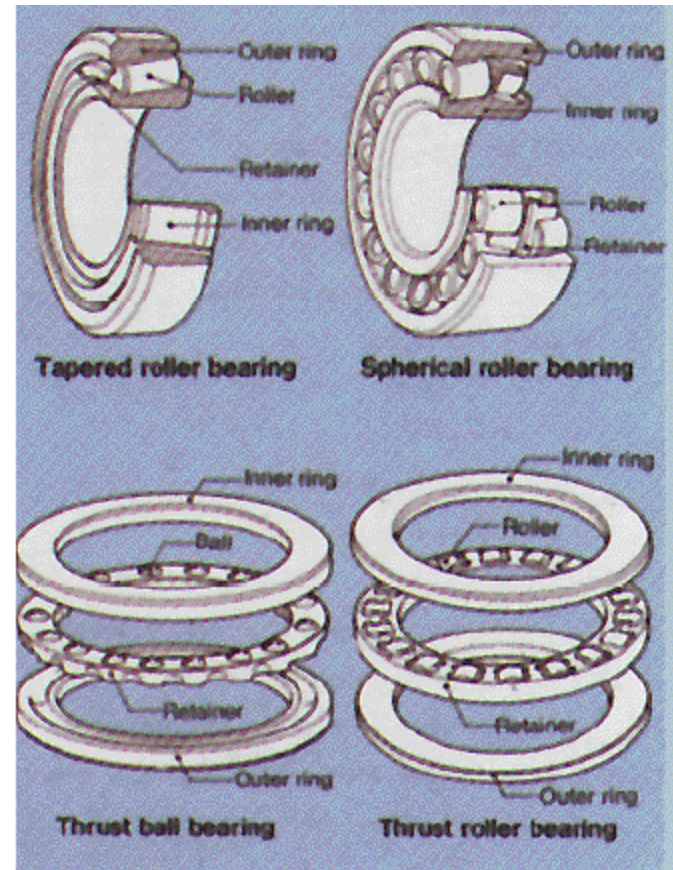
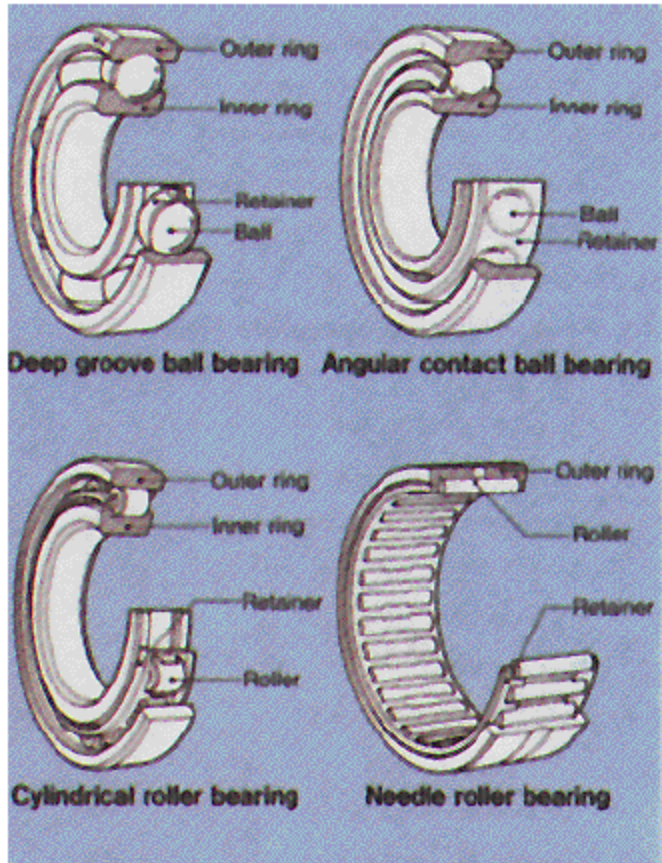


Radial ball bearing

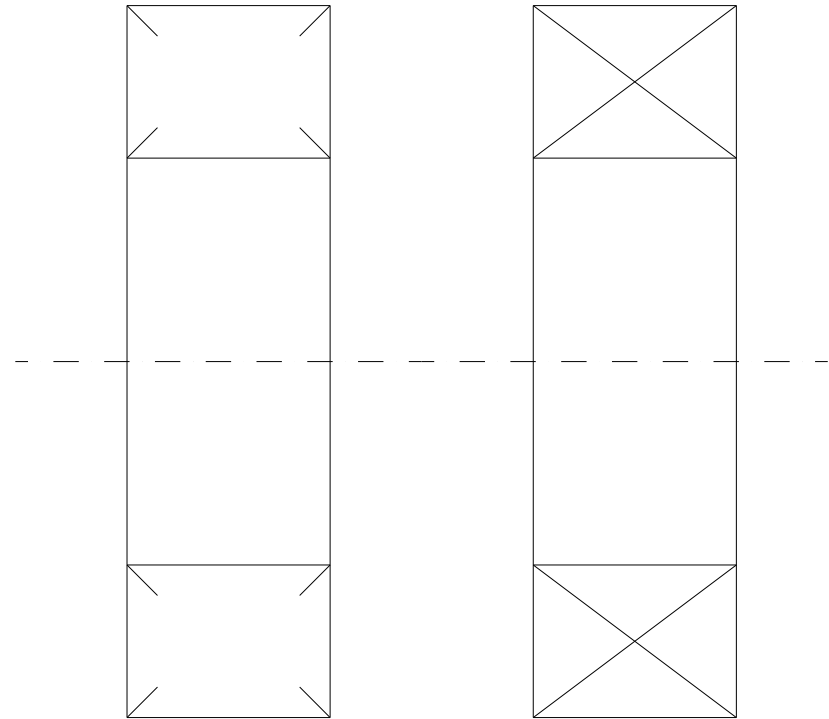
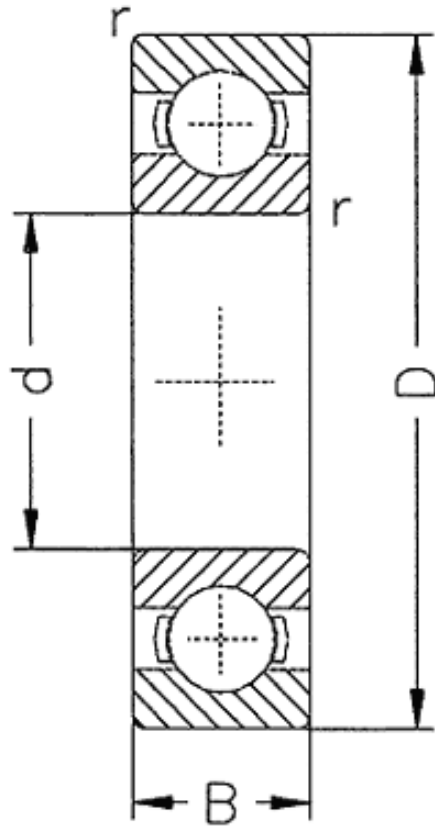


Thrust ball bearing

Ball and roller bearings



Ball and roller bearings

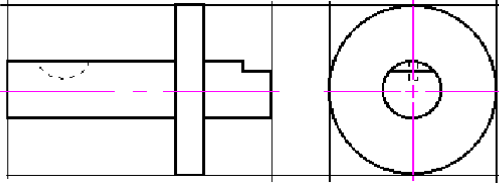
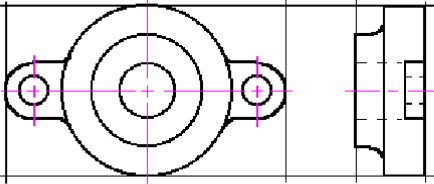
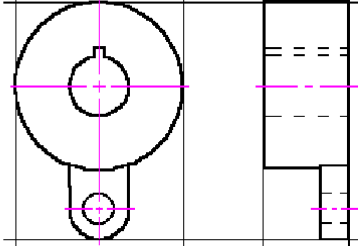



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Working drawings

- One working drawing is made for each non-standard component
- All the necessary information to carry out manufacturing must be contained within the drawing
- Recommendation: use a reference (textbook) when draw a working drawing
- Assembly working drawing contain the necessary information to perform the assembly of the system

Working drawings

BILL OF MATERIALS			
ITEM	QUAN.	DRAWING NO. OR PART NAME	DESCRIPTION
			
1. PIN DOWEL			
			
3. BRACKET			
			
2. SLINGER			

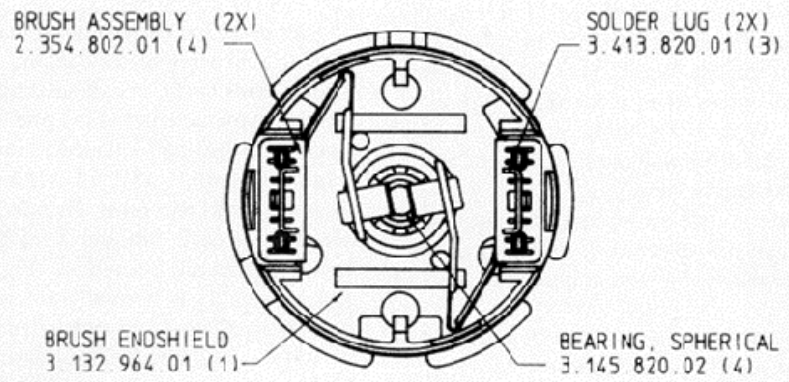
NUMBER REQ:	MATERIAL:	FINISH:		RICHARD D. IRWIN
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS = ± .XX DECIMALS = ± .XXX DECIMALS = ± ANGLES: ± .XX METRIC = ± .XXX METRIC = ±	WEIGHT:	NAME	DATE	TITLE
	DRAWN BY:	Kevin		SLINGER ASSEMBLY
	CHECKED BY:	Bryan		
	APPROVED BY:	Carolyn		REFERENCE DRAWING
	SCALE:		C	DRAWING NUMBER

66 11 65-80-10
30mm

Für diese Zeichnung behalten wir uns alle Rechte nach DIN 34 1er.

DRAWING CREATED WITH ISO STANDARDS

Tolerance unless otherwise stated			Tolerance of angle (See Table of Angles)			Surface Finish	Dimension	Tolerance
up to 6	over 6 up to 30	over 30 up to 120	up to 15	over 15 up to 30	over 30 up to 180			
±0.1	±0.2	±0.3	±1°	±30'	±20'			



NOTES:

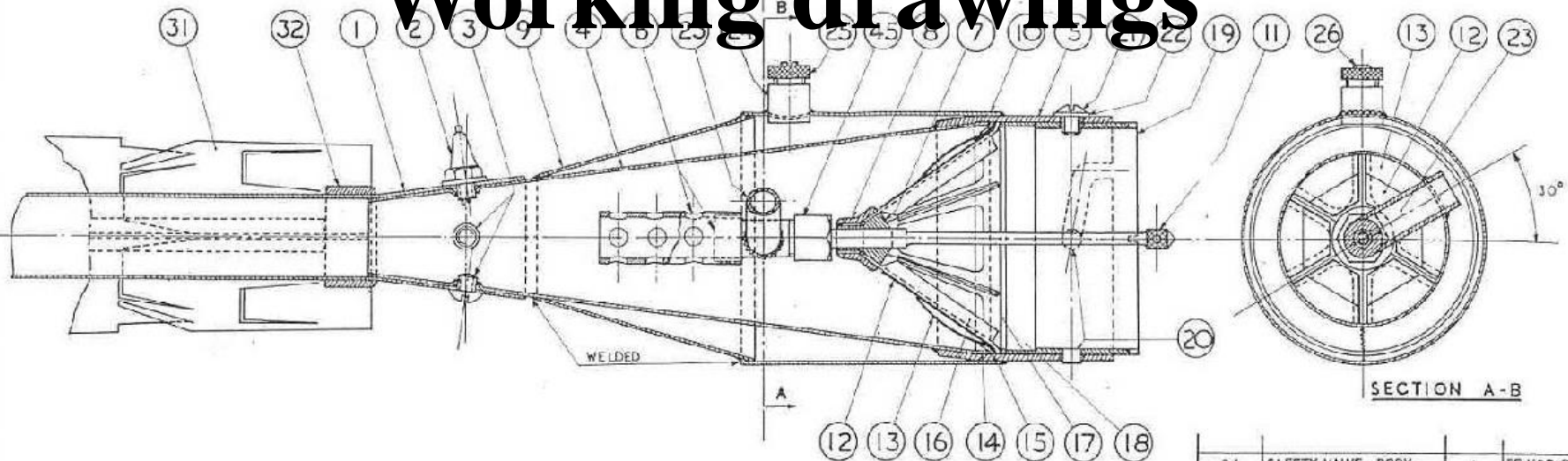
- BRUSH ASSEMBLIES (2.354) AND SOLDER LUGS (3.413) TO BE FULLY SEATED.
- SOLDER LUG (3.413) TO WITHSTAND 30N MINIMUM PUSH-OUT FORCE AFTER ASSEMBLY.

- 01
PI KN

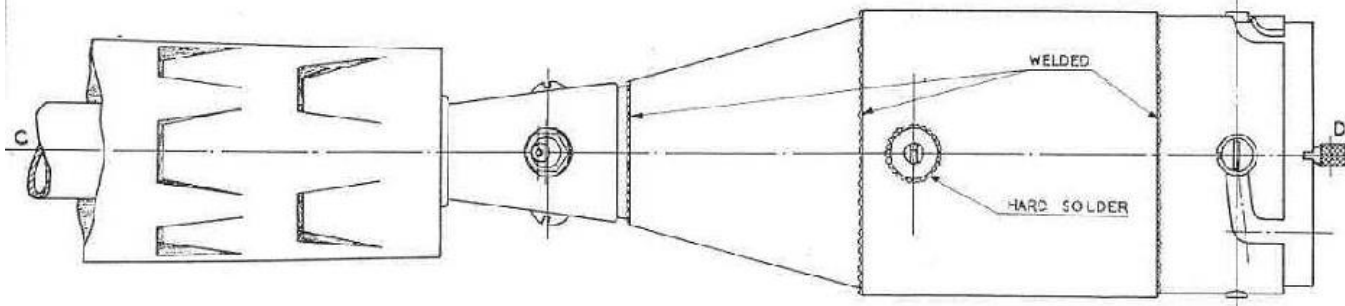
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ISO-E		Material Number		Internal	
BUCHLER PRODUCTS INC. RALEIGH, NC 27634		Date	29MAY93	Substituted For	
		Drawn	MCMILLAN		
		Check	MCMILLAN	Replaced By	
		Appr	9/24		
Title				Scale	
ENDSHIELD ASSEMBLY				2:1	
Esper No				Sheet	
E2.132.01586				1	
Drawing Number				of	
2.132.937.KN (4)				1	
1	RELEASED PER ECO 3271-140	29MAY93	JEM	13 56	
01	Change Only With CAD	Date	Name	Use	

Working drawings



LONGITUDINAL SECTION C-D

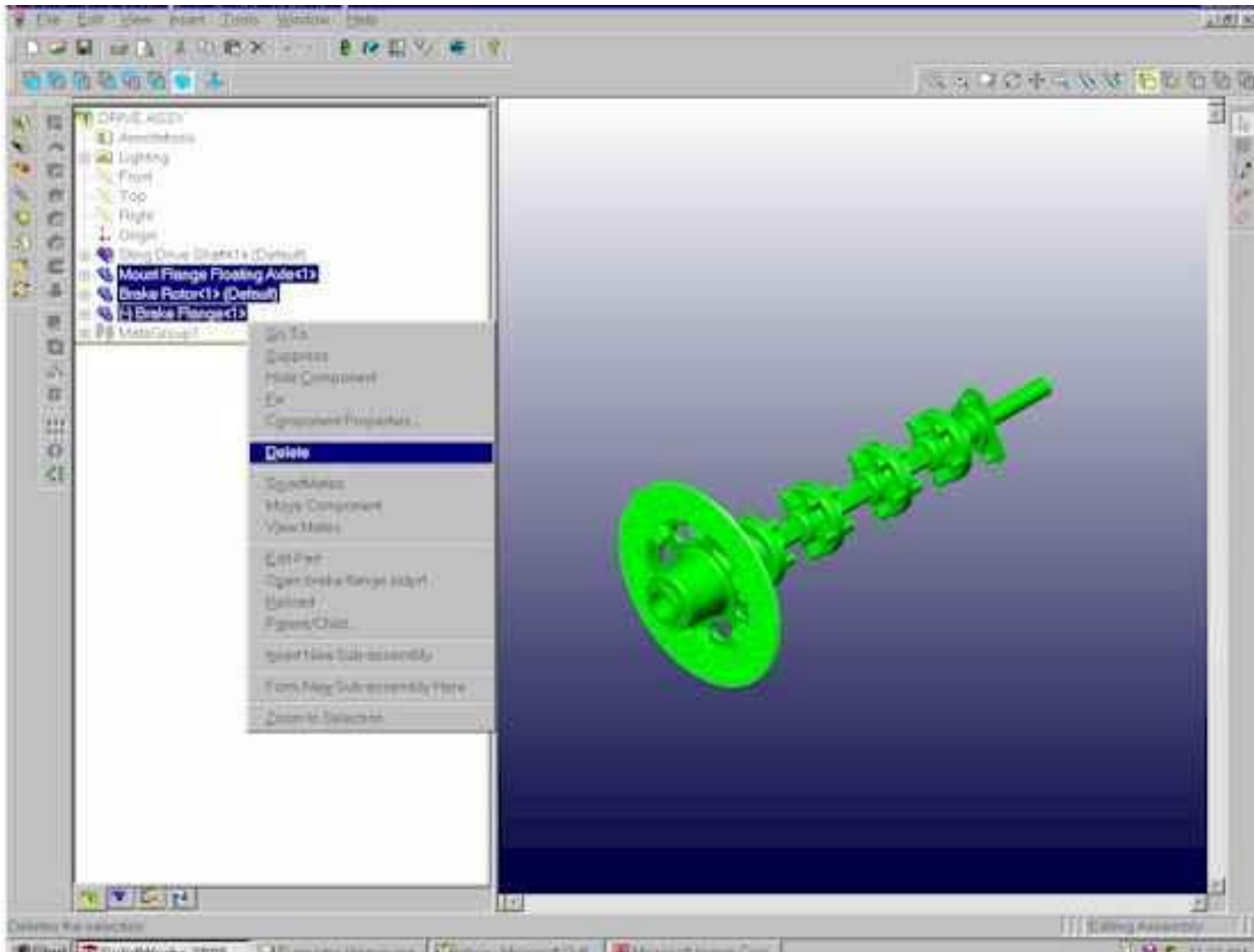


GENERAL ASSEMBLY

49	LOCK NUT	1	DR. N°9 - PARTS
32	RETAINING RING	2	
31	MELOT NOZZLE	2	
26	SAR. VALVE SPRING RETAIN.	1	
25	SAFETY VALVE PLUG	1	
PARTS	NAME	Q	REMARKS

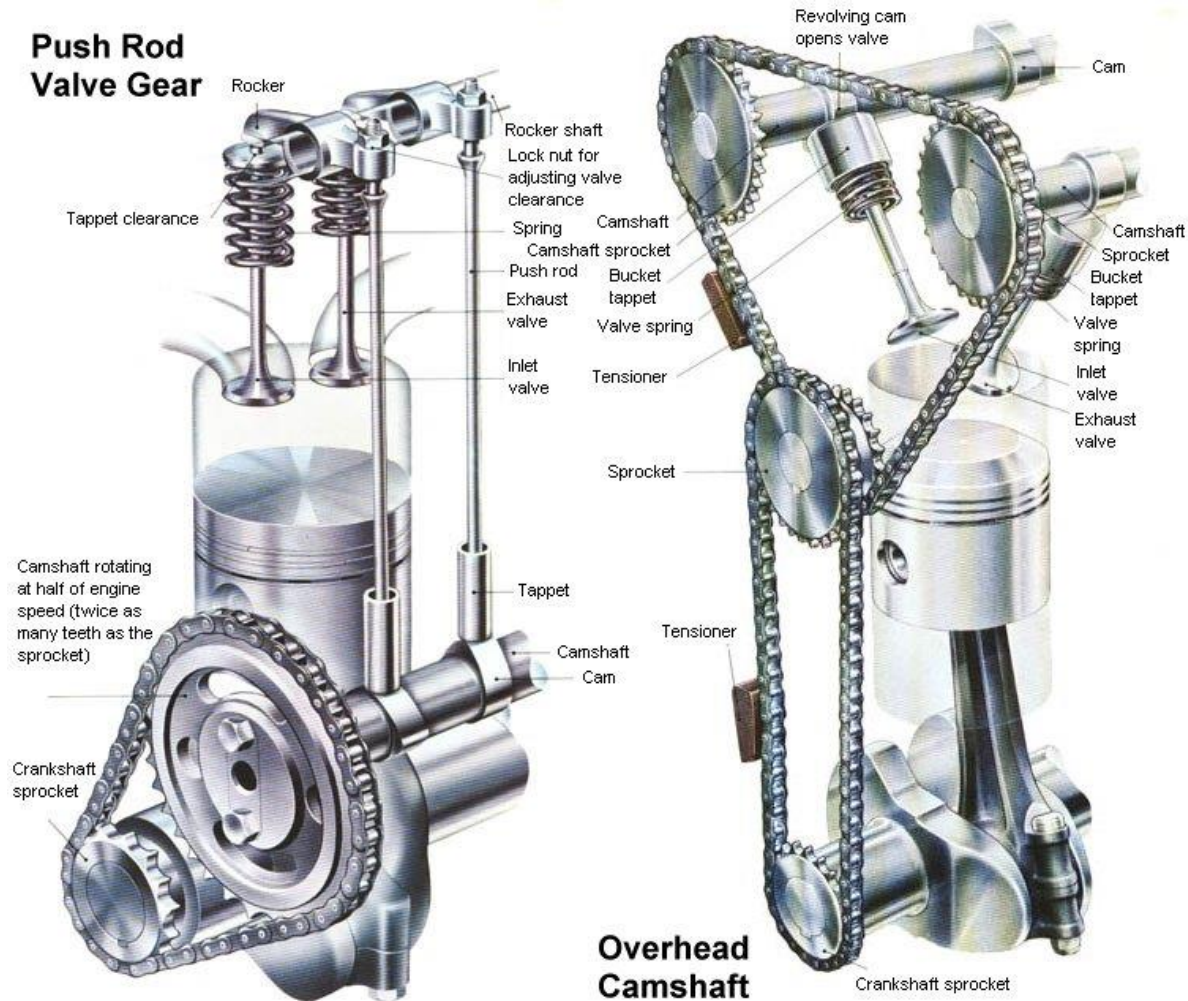
24	SAFETY VALVE - BODY	1	DR. N°6 PART 14
23	INLET TUBE	1	
22	SPRING WASHER	1	STAND.
21	BAYONET LUG LOCK SCR.	1	B. A. N°2
20	BAYONET LUGS	3	
19	LOCKING RETAINER	1	
18	FRONT SPACER RING	1	
17	INTAKE VALVE FRAME RING	1	
16	INTAKE VALVE FRAME ELEM.	6	
15	VALVE LEAF RETAINER	1	
14	REAR SPACER RING	1	
13	INTAKE VALVE LEAF STIFFEN.	6	
12	INTAKE VALVE LEAF	6	
11	NEEDLE	1	
10	FUEL JACKET-CYLINDER	1	
9	FUEL JACKET-CONE	1	
8	VALVE LOCK NUT	1	
7	VALVE BODY	1	
5	INJECTOR	1	DR. N°5 PARTS
5	FRONT RING	1	
4	MOTOR BODY	1	
3	SCREW-ROUND HEAD	3	3/16" DIA.
2	SPARK PLUG	1	STAND. MOD.
1	EX-HAUST TUBE	1	
PARTS	NAME	Q	REMARKS
JET MOTOR MODEL Z.M.E.			
DR. BY	CHECKED/APP. BY	SCALE: FULL	DATE 3/20/45
	Z.F.		
AIRCRAFT-JET & ROCKET CORP.			DR. N° 1.

Working drawings

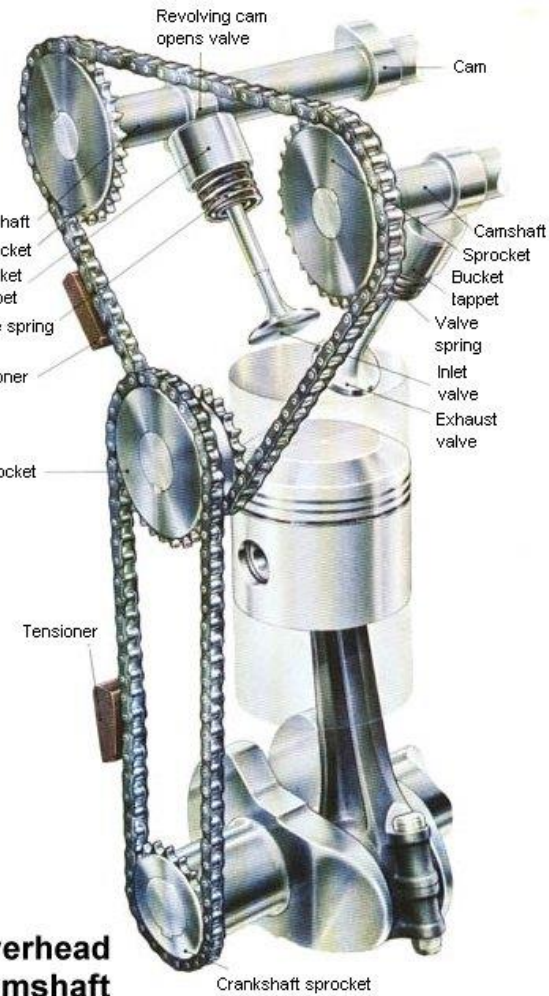


Example of mechanisms

Push Rod Valve Gear

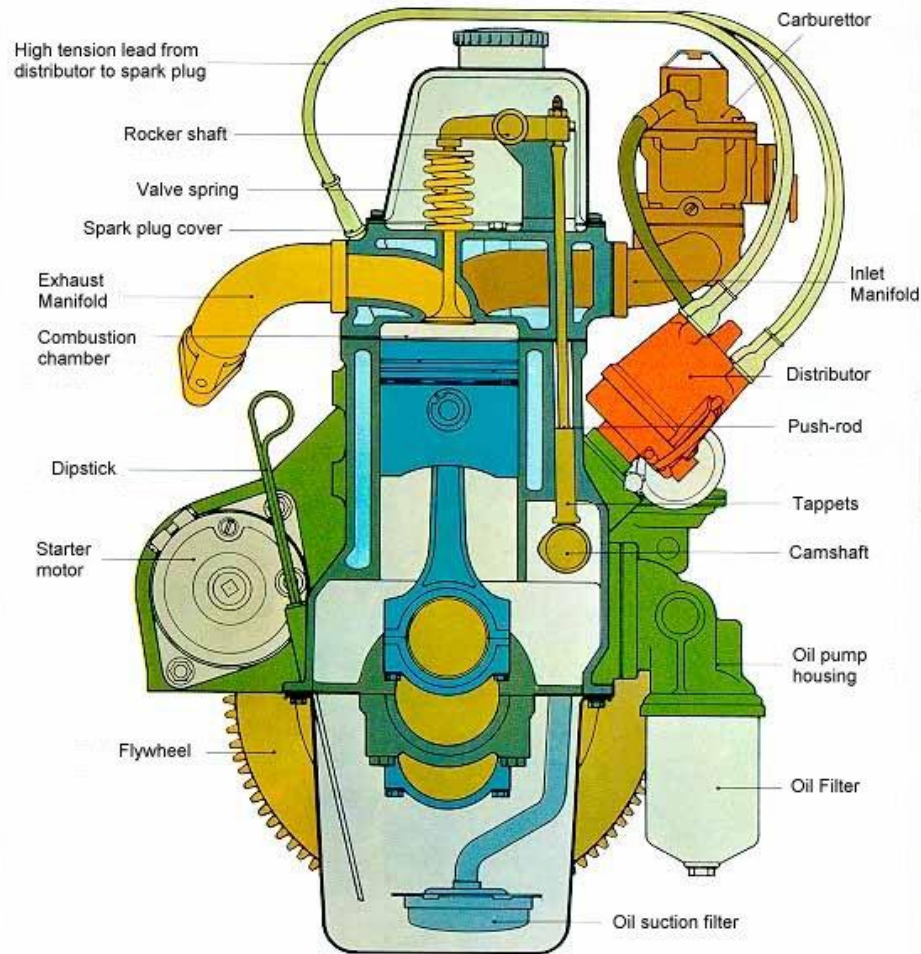


Overhead Camshaft

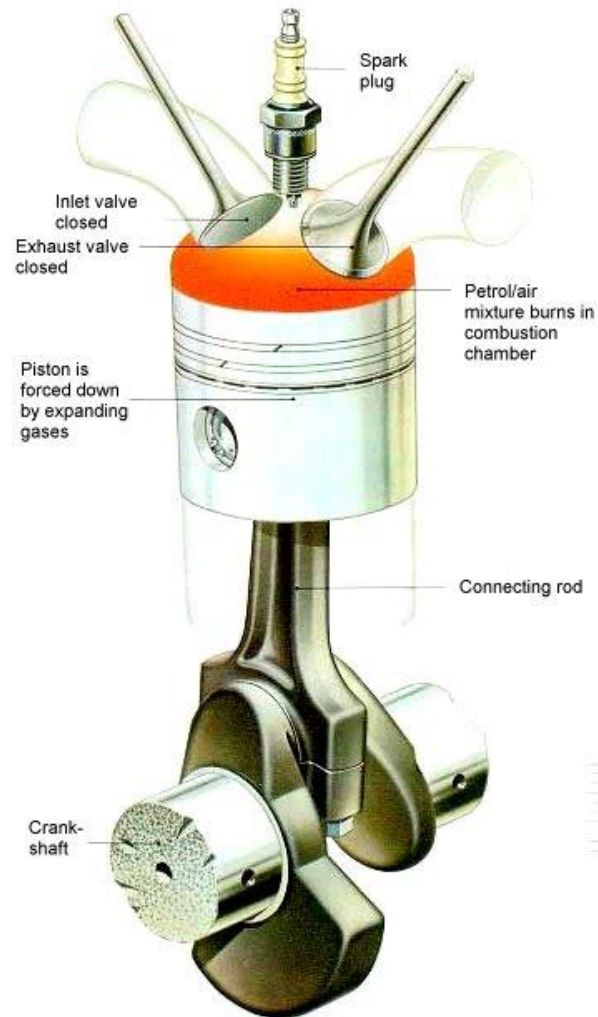


Example of mechanisms

FRONT SECTION OF A 4-CYLINDER INTERNAL COMBUSTION ENGINE



Example of mechanisms



Example of mechanisms

