

Computer-Aided Design

Machine Elements |

MACHINE ELEMENTS

➤ Mechanical Fastening

- Bolts, nuts, screws, washers, keys, pins *removable*

➤ Bonding *permenint maching*

- Welding, soldering, brazing, gluing, riveting



Bolts and nuts



rivet



washers



screws

DRAWING STANDARD MACHINE ELEMENT

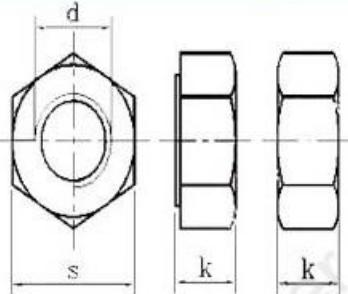
Check this: <https://www.trfastenings.com/Products/Catalogue/nuts>

BS EN ISO 4032 Hexagon nuts style 1 – product grades A and B

Standard & CAD & Supplier-Global Fastener Platform

Nuts

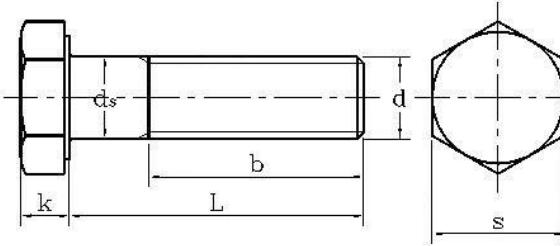
AS 1112-1 ISO Metric Hexagon Nuts



Unit: mm

d	Pitch P	k		s	
		max	min	max	min
M1.6	0.35	1.3	1.05	3.2	3.02
M2	0.4	1.6	1.35	4	3.82
M2.5	0.45	2	1.75	5	4.82
M3	0.5	2.4	2.15	5.5	5.32
M3.5	0.6	2.8	2.55	6	5.82
M4	0.7	3.2	2.9	7	6.78
M5	0.8	4.7	4.4	8	7.78
M6	1	5.2	4.9	10	9.78
M8	1.25	6.8	6.44	13	12.73
M10	1.5	8.4	8.04	16	15.73
M12	1.75	10.8	10.37	18	17.73
M14	2	12.8	12.1	21	20.67
M16	2	14.8	14.1	24	23.67
M18	2.5	15.8	15.1	27	26.16
M20	2.5	18	16.9	30	29.16

Bolt



Unit: mm

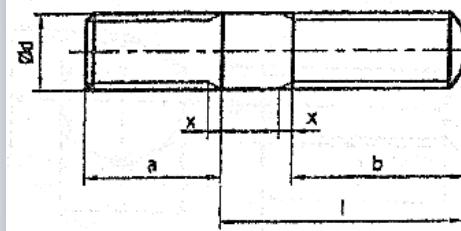
d	P	b			ds		k		s	
		L<125	125<L<200	200<L	max	min	max	min	max	min
M5	0.8	16	22	35	5.48	4.52	3.875	3.125	8	7.64
M6	1	18	24	37	6.48	5.52	4.375	3.625	10	9.64
M8	1.25	22	28	41	8.58	7.42	5.675	4.925	13	12.57
M10	1.5	26	32	45	10.58	9.42	6.85	5.95	16	15.57
M12	1.75	30	36	49	12.70	11.30	7.95	7.05	18	17.57
M14	2	34	40	53	14.70	13.30	9.25	8.35	21	20.16
M16	2	38	44	57	16.70	15.30	10.75	9.25	24	23.16
M18	2.5	42	48	61	18.70	17.30	12.40	10.60	27	26.16
M20	2.5	46	52	65	20.84	19.16	13.40	11.60	30	29.16
M22	2.5	50	56	69	22.84	21.16	14.90	13.10	34	33
M24	3	54	60	73	24.84	23.16	15.90	14.10	36	35
M27	3	60	66	79	27.84	26.16	17.90	16.10	41	40
M30	3.5	66	72	85	30.84	29.16	19.75	17.65	46	45
M33	3.5	/	78	91	34.00	32.00	22.05	19.95	50	49
M36	4	/	84	97	37.00	35.00	23.55	21.45	55	53.8
M39	4	/	90	103	40	38	26.05	23.95	60	58.8
M42	4.5	/	96	109	43.00	41.00	27.05	24.95	65	63.1
M45	4.5	/	102	115	46	44	29.05	26.95	70	68.1
M48	5	/	108	121	49.00	47.00	31.05	28.95	75	73.1
M52	5	/	116	129	53.2	50.8	34.25	31.75	80	78.1
M56	5.5	/	137	57.20	54.80	36.25	33.75	85	82.8	
M60	5.5	/	/	145	61.2	58.8	39.25	36.75	90	87.8
M64	6	/	/	153	65.20	62.80	41.25	38.75	95	92.8



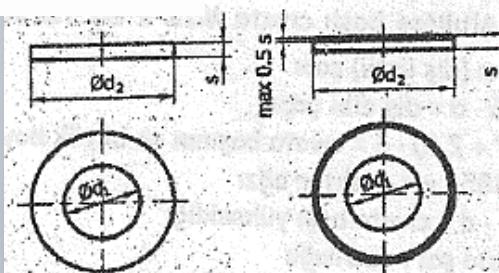
d: 020



Stud M12 x 80 TS 1025/4 - 8.8



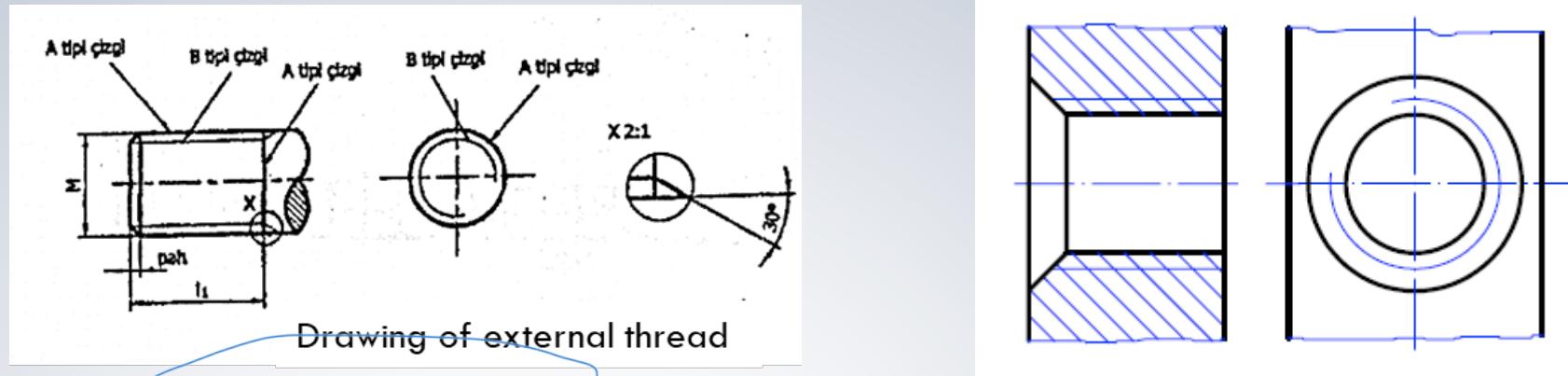
Washer A 10.5 TS 79/2



THREADED FASTENERS

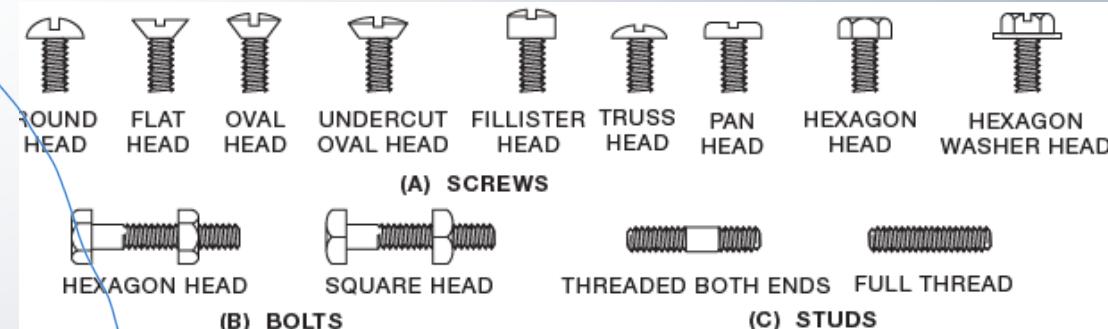
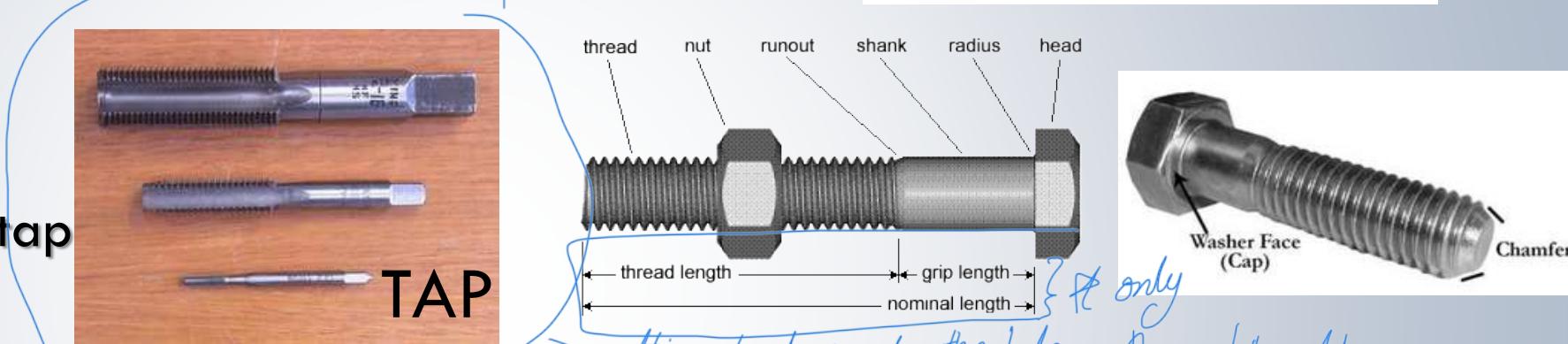
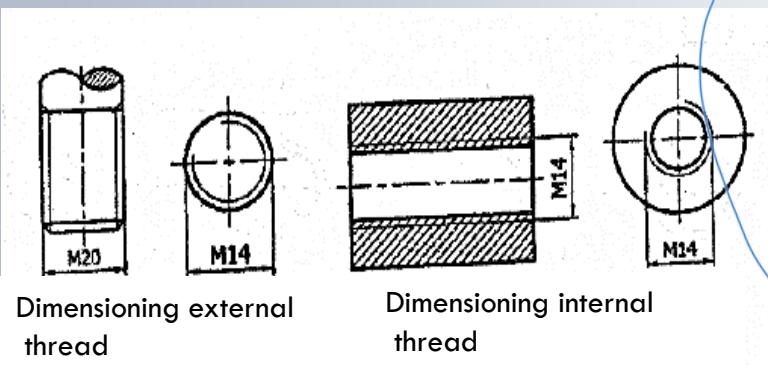
Internal threads

- Threads inside a hole
- Made by drill & tap:
 - drill smooth hole
 - make threads with a tap



External threads

- Threads outside a cylinder
- Made with a die
- Made by rolling



THREADED FASTENERS



Internal threads

- Threads inside a hole
- Made by drill & tap:
 - drill smooth hole
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External threads

- Threads outside a cylinder
- Made with a die
- Made by rolling

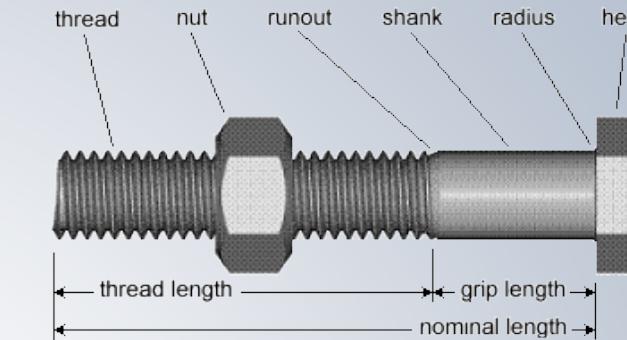
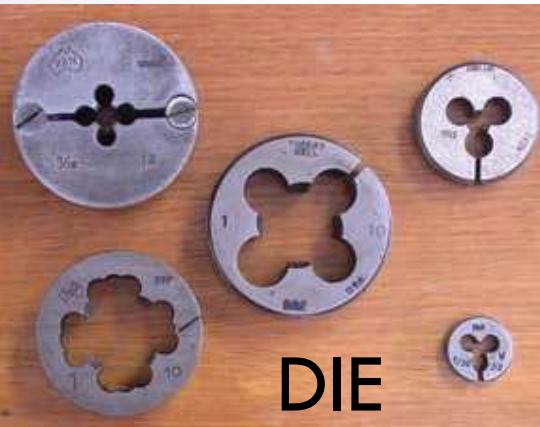
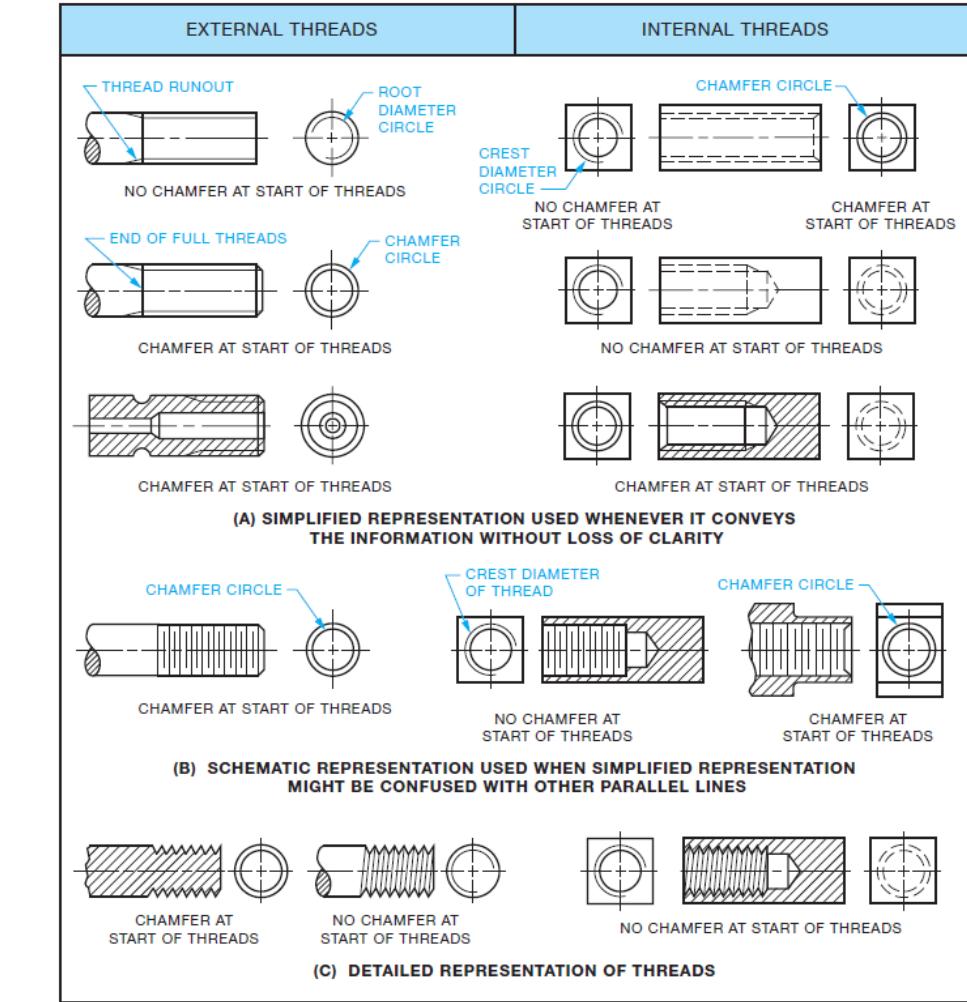


FIGURE 16-3 Standard thread representations based on ISO and CSA standards.



CUTTING SCREW THREADS

Methods for producing external threads

- Single-point thread cutting
- Threading die
- Thread chasing using self-opening threading dies
- Thread milling

Methods for producing internal threads

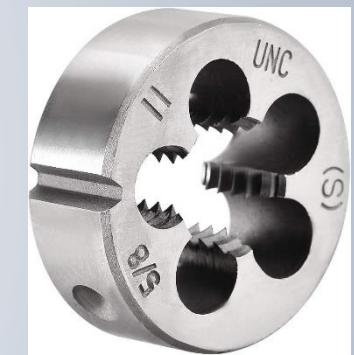
- Tapping - using a solid tap
- Collapsible taps - cutting teeth retract for quick removal from hole



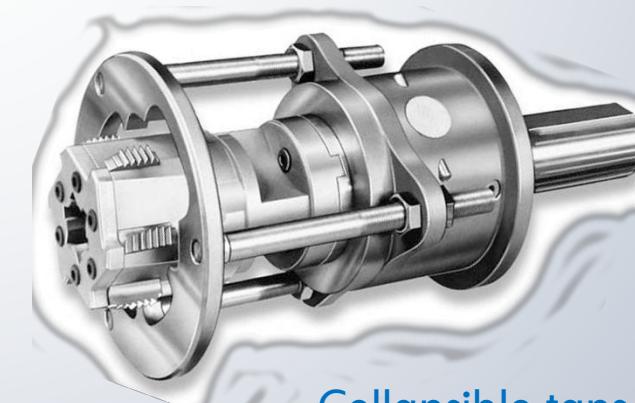
Self-opening T.D.



Die stock



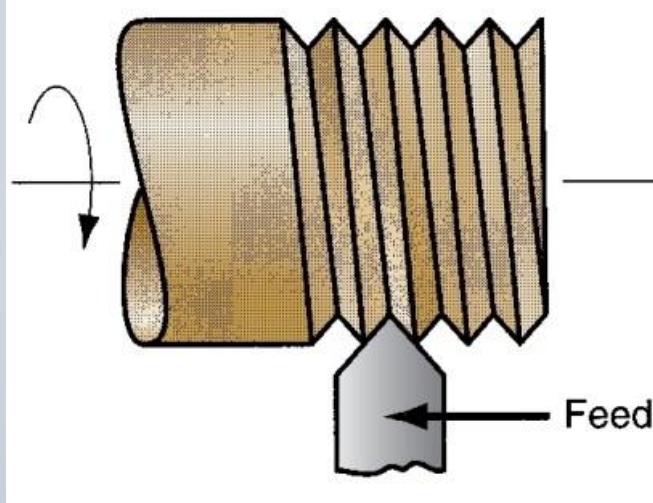
Threading die



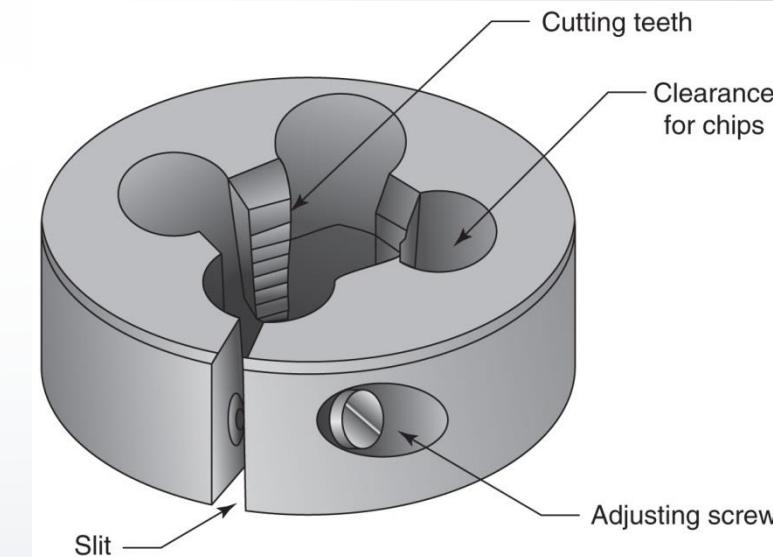
Collapsible taps

CUTTING EXTERNAL SCREW THREADS

(a) Single-point thread cutting and (b) threading die

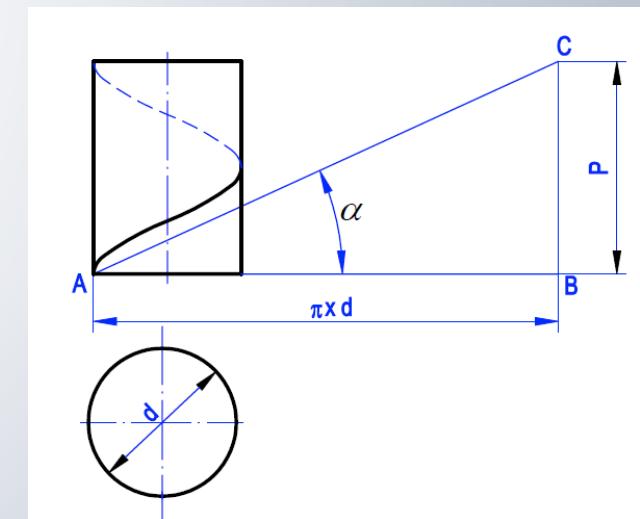
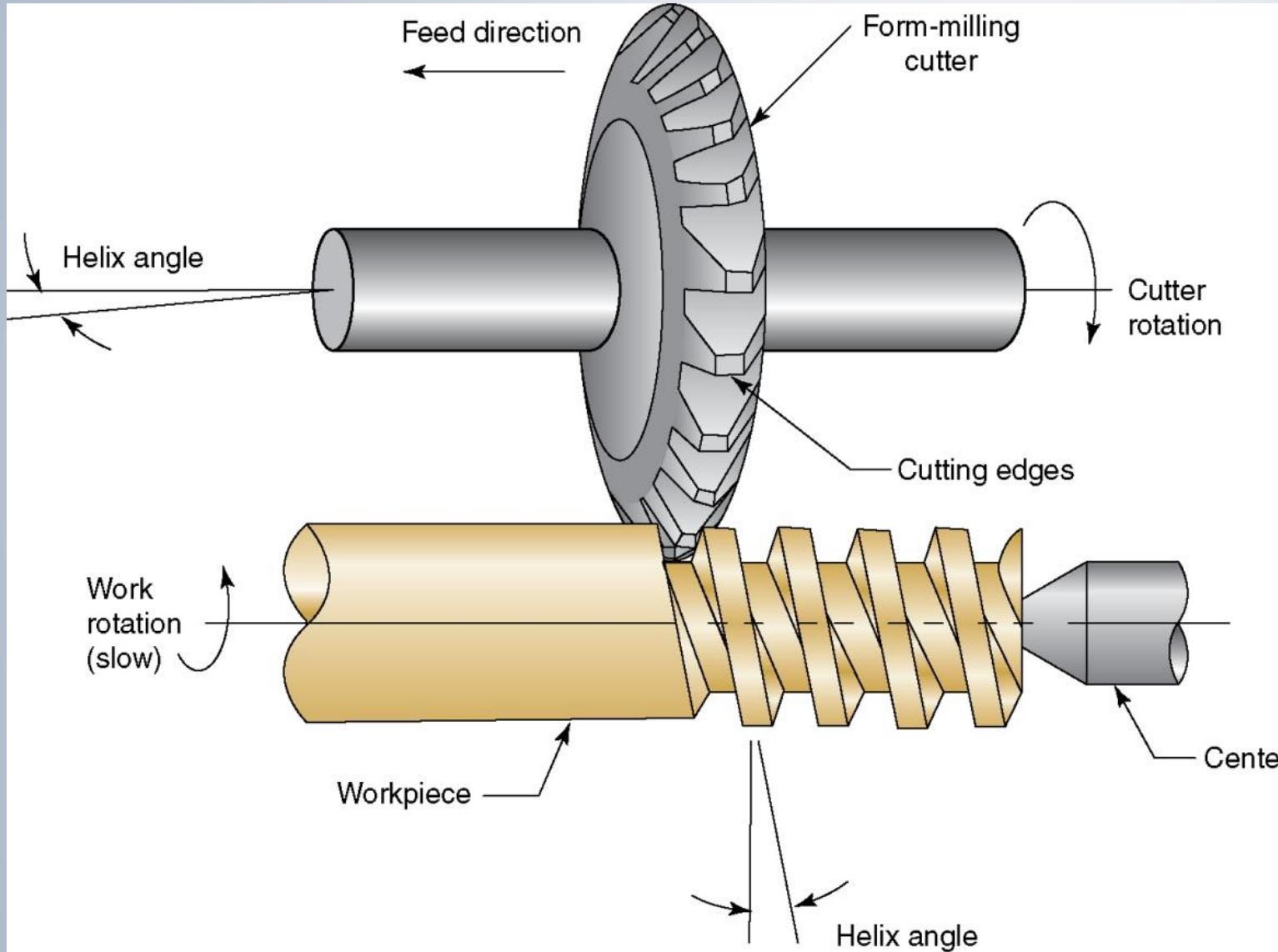


(a)

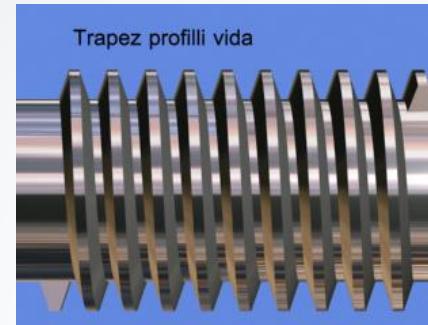
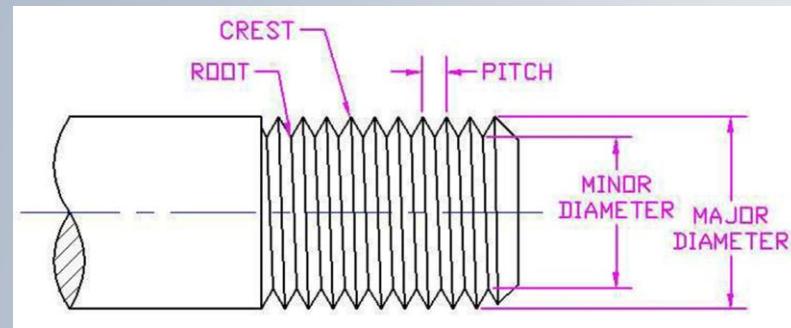


(b)

THREAD MILLING USING A FORM-MILLING CUTTER

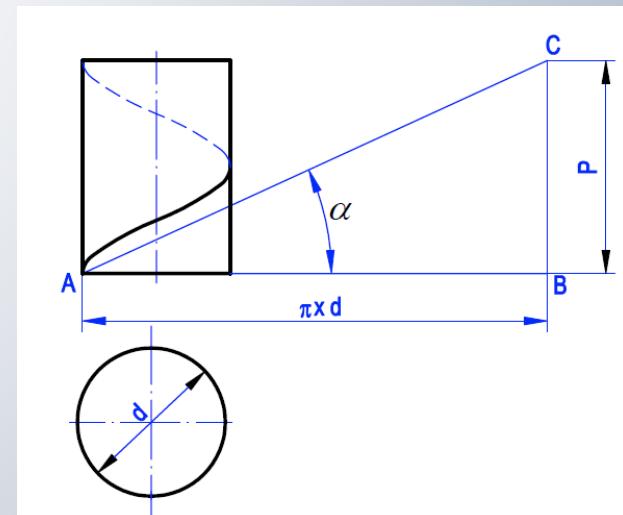
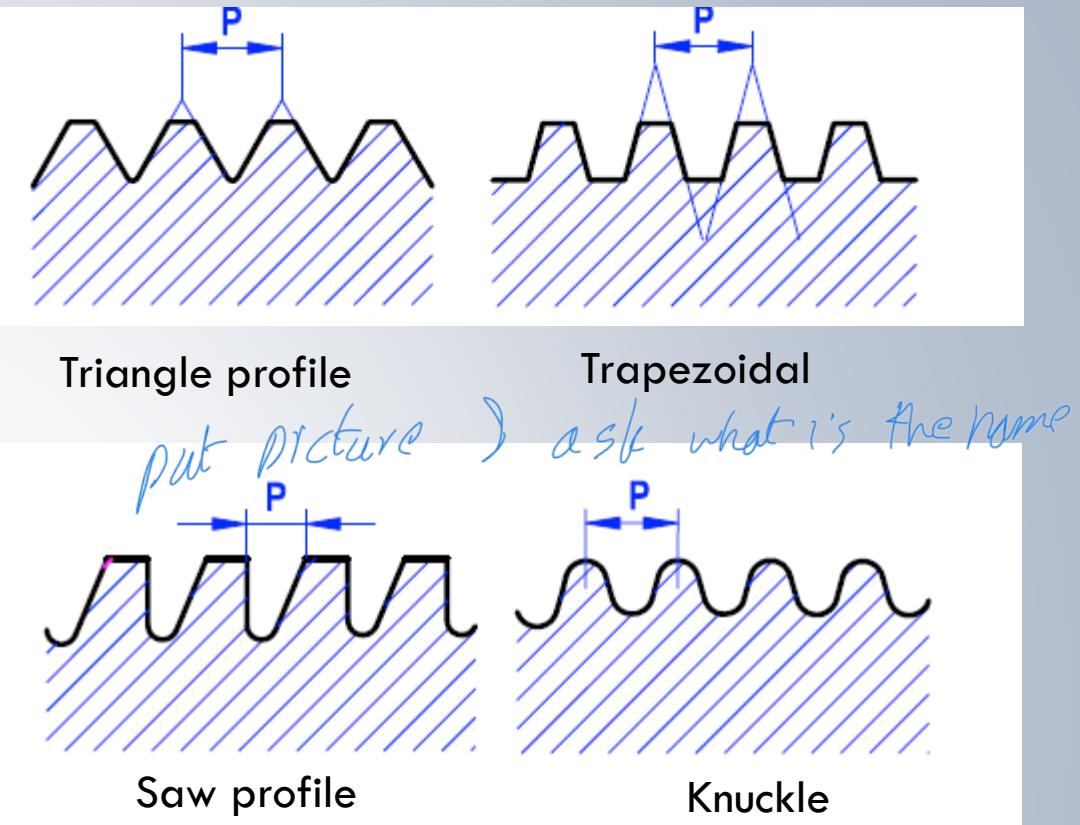


THREADED FASTENERS



Type of thread	Designation	Sample
Metric (coarse)	M	M16
Metric (fine)	M	M16 x 1,5
Unified screw thread		1/2
Pipethread	G	G1/4
Pipe taper thread	R	R1/4
Trapezoidal thread (symetric)	Tr	Tr24x5
Buttress thread	S	S24x5
Knuckle thread	Rd	Rd32x1/8
Left-hand thread	LH	M16LH
Multiple thread	P...	M60x4(P3)

angle for more strength against
smooth movement
high load
both directions

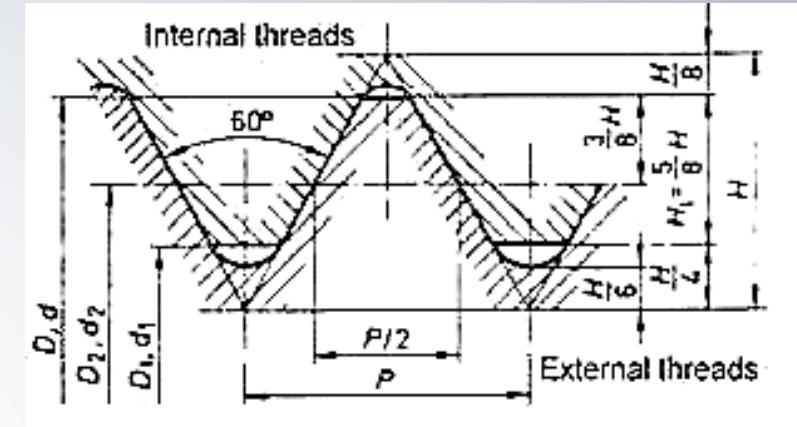


SCREW THREAD EXAMPLE

- thread angle = 60°
- symmetric profiles
- identified as M
- coarse and fine pitch
- specification of the thread

M12 x 1.75

- the metric thread designation (M)
- nominal major diameter (12 mm)
- pitch (1,75 mm)



THROUGH HOLE AND BLIND HOLE

➤ A "thru hole" passing through the part or a "blind hole" in the part that shows the form of the drill bit

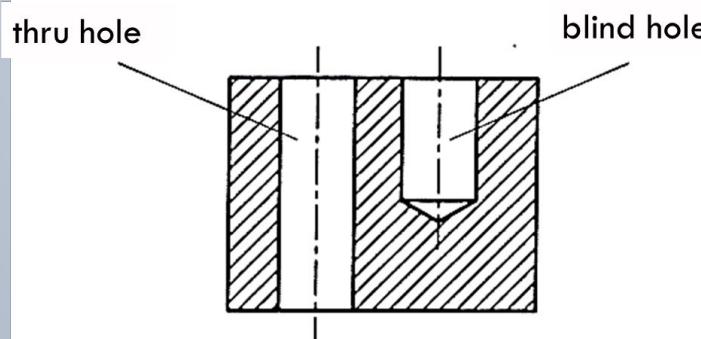
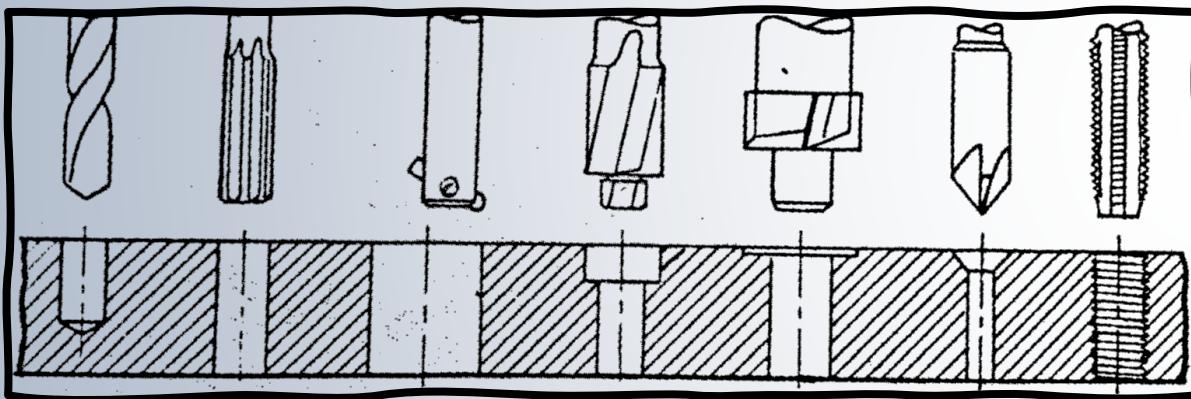
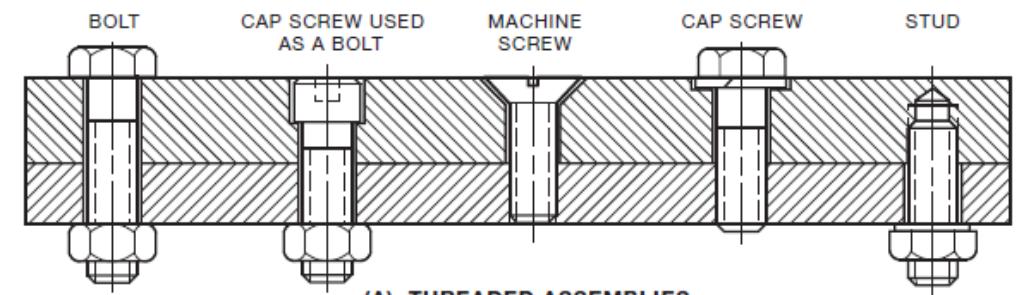
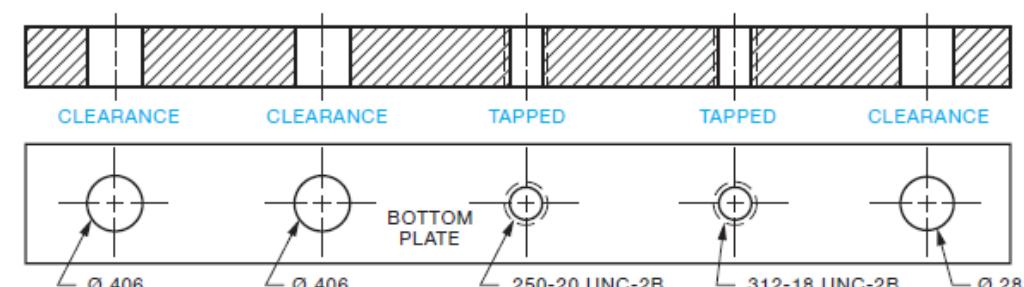
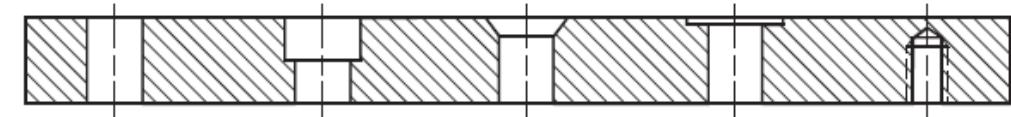
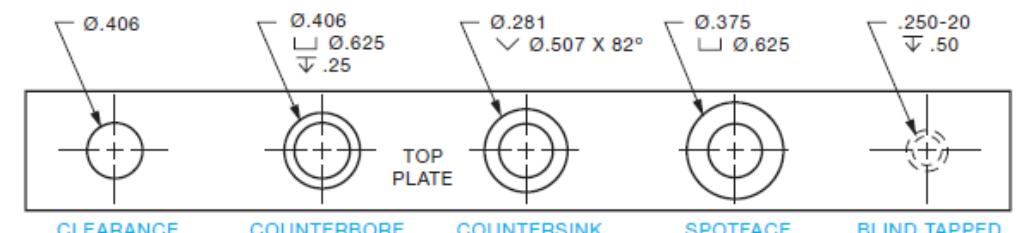


FIGURE 16-6 Common threaded fasteners.



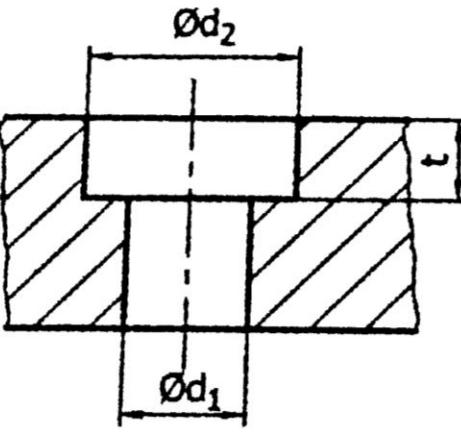
(A) THREADED ASSEMBLIES



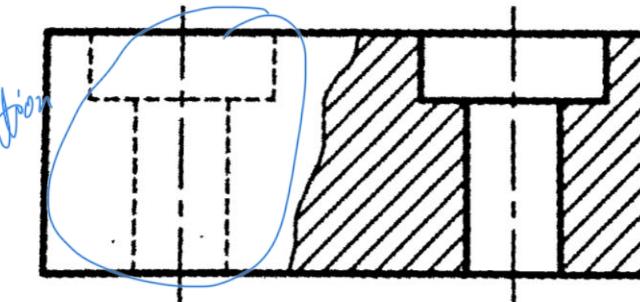
(B) DIMENSIONING HOLES

COUNTERBORE HOLES

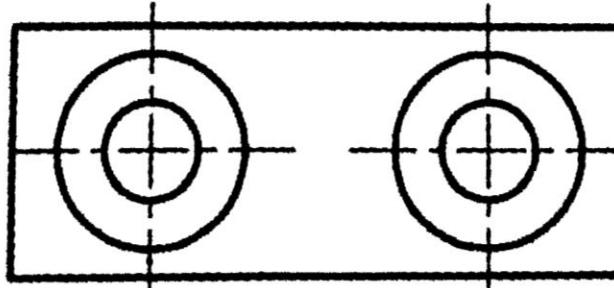
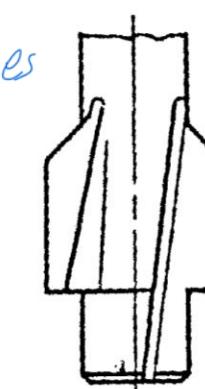
related bolt	$\varnothing d_1$	$\varnothing d_2$	t
M5	5.5	10	4
M6	6.6	11	4.7
M8	9	15	6
M10	11	18	7



No dimension in hidden lines



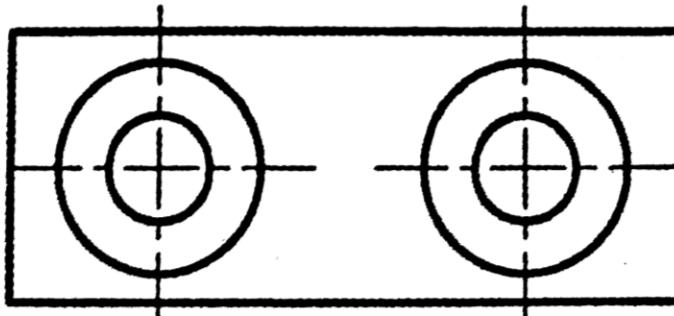
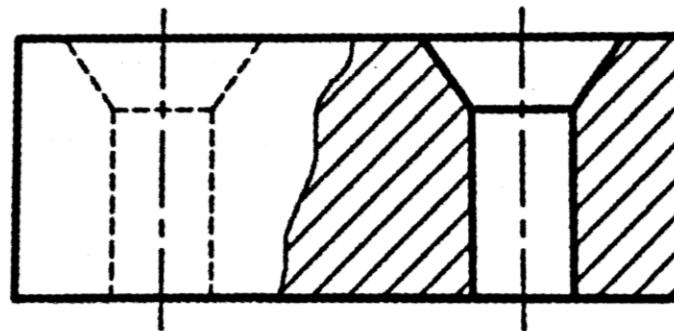
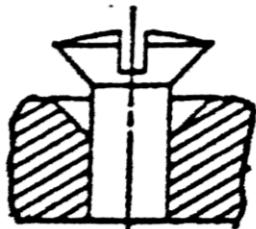
No dimension in hidden lines

COUNTERSINK BOLT HOLES

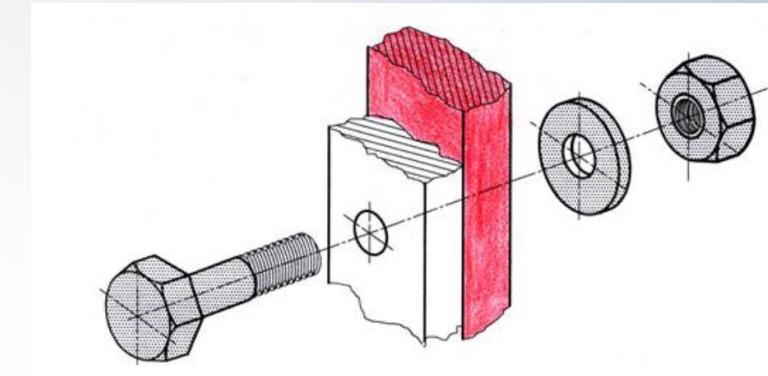
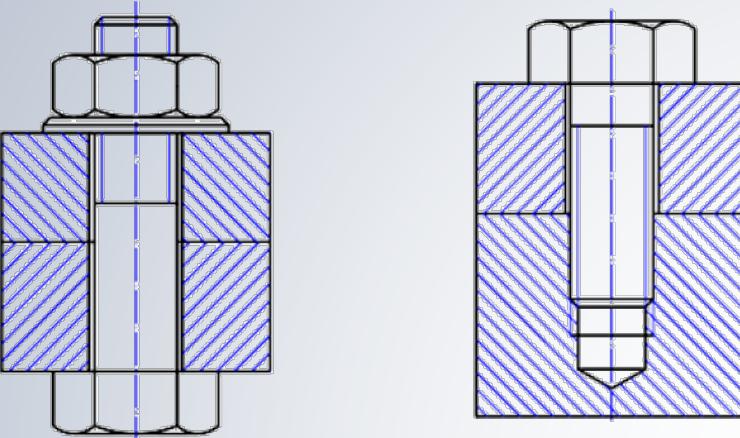
related bolt	$\varnothing d_1$	$\varnothing d_2$	t
M5	5.5	10.4	2.5
M6	6.6	12.4	2.9
M8	9	16.4	3.7
M10	11	20.4	4.7

Countersink bolt

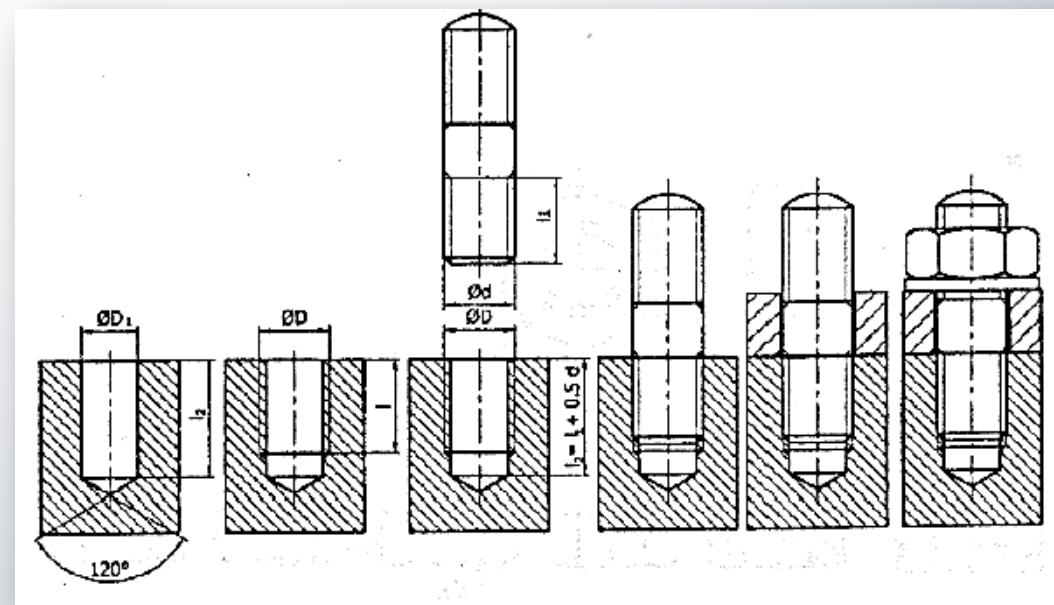
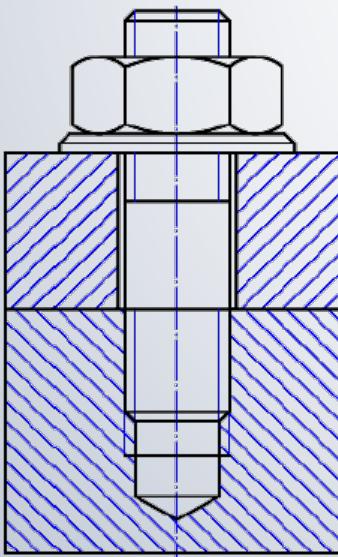


FASTENER ASSEMBLY

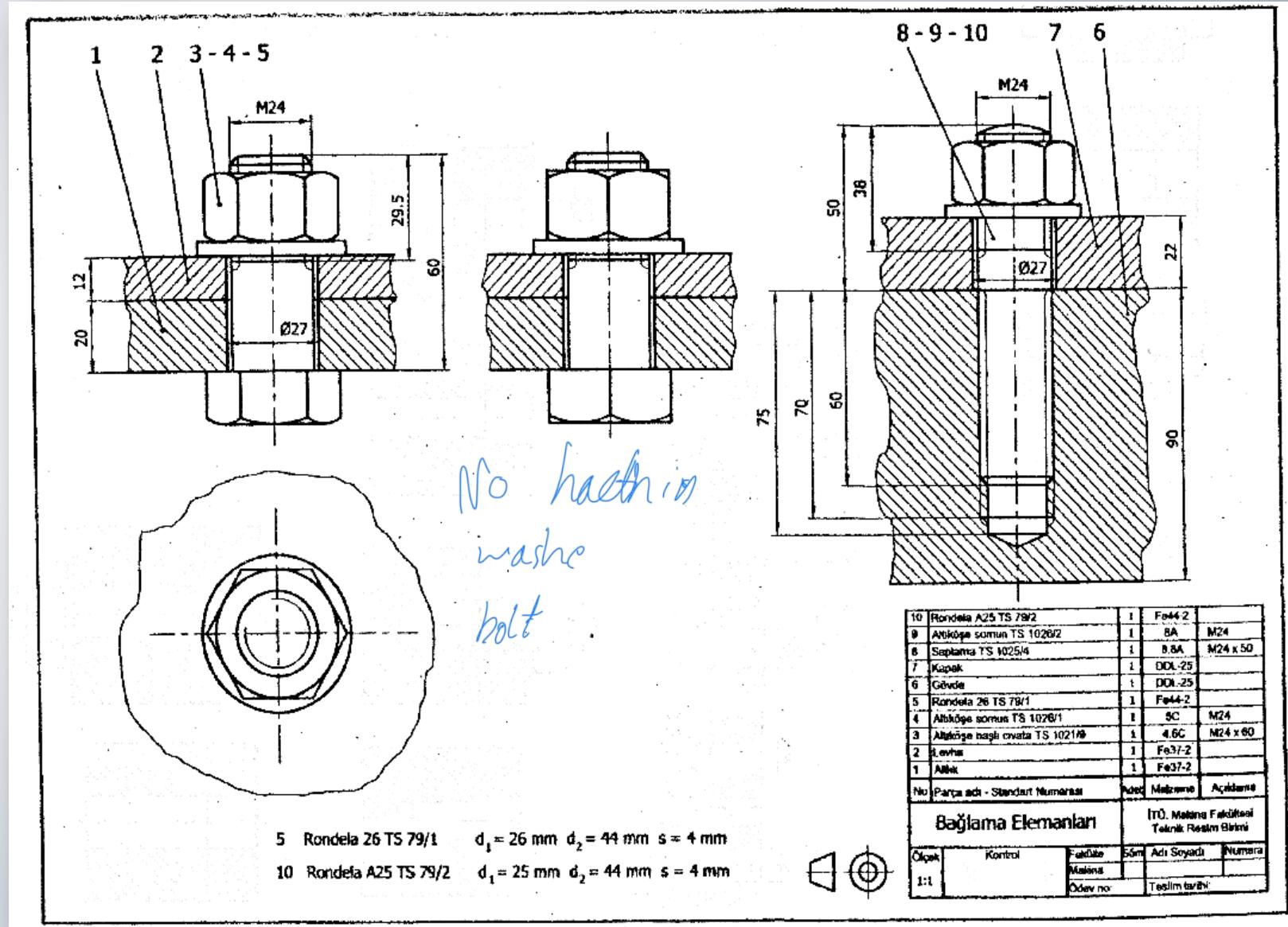
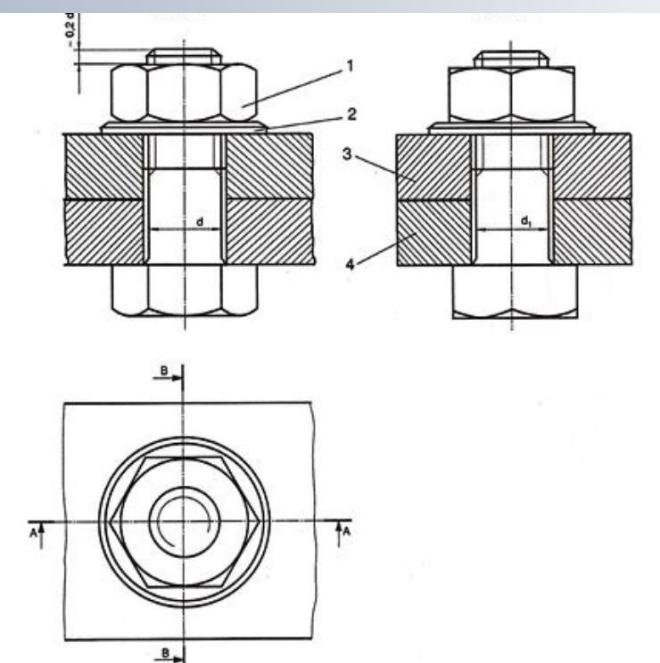
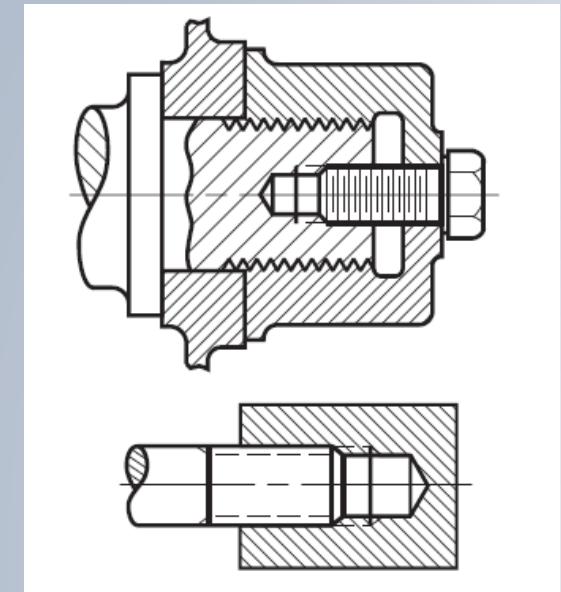
Bolt



Stud



FASTENER ASSEMBLY



MACHINE ELEMENTS

Bearing selection: <https://skfbearingselect.com/#/bearing-selection-start>

➤ Gear wheels



➤ Bearings



➤ Couplings

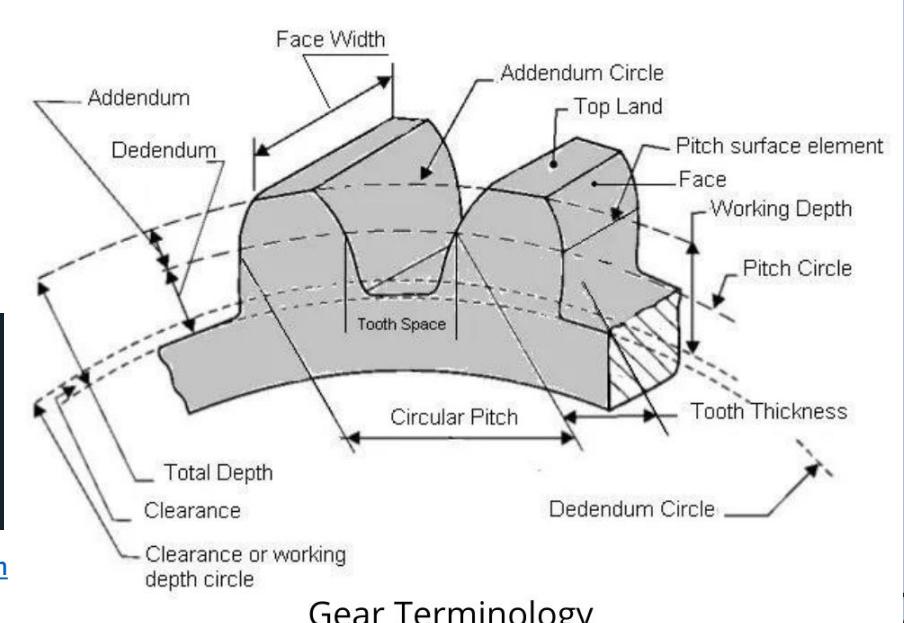
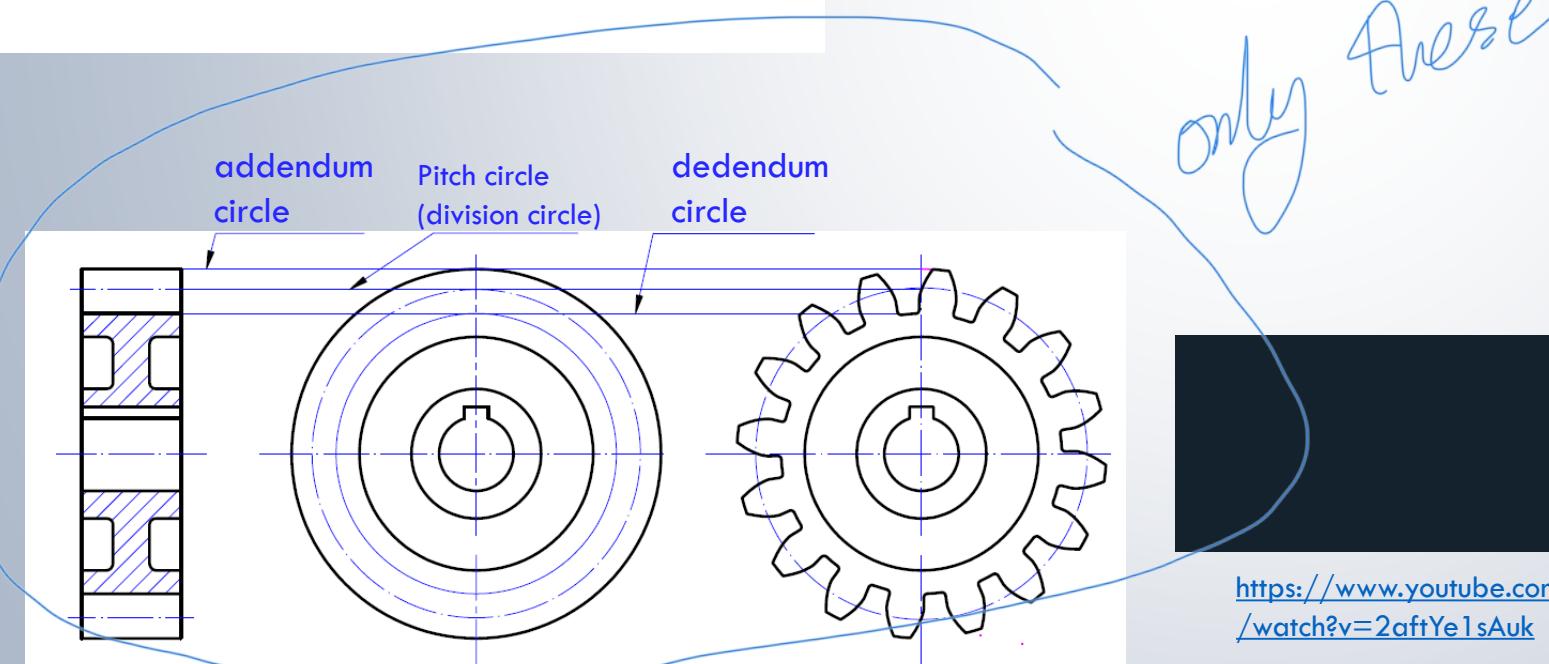
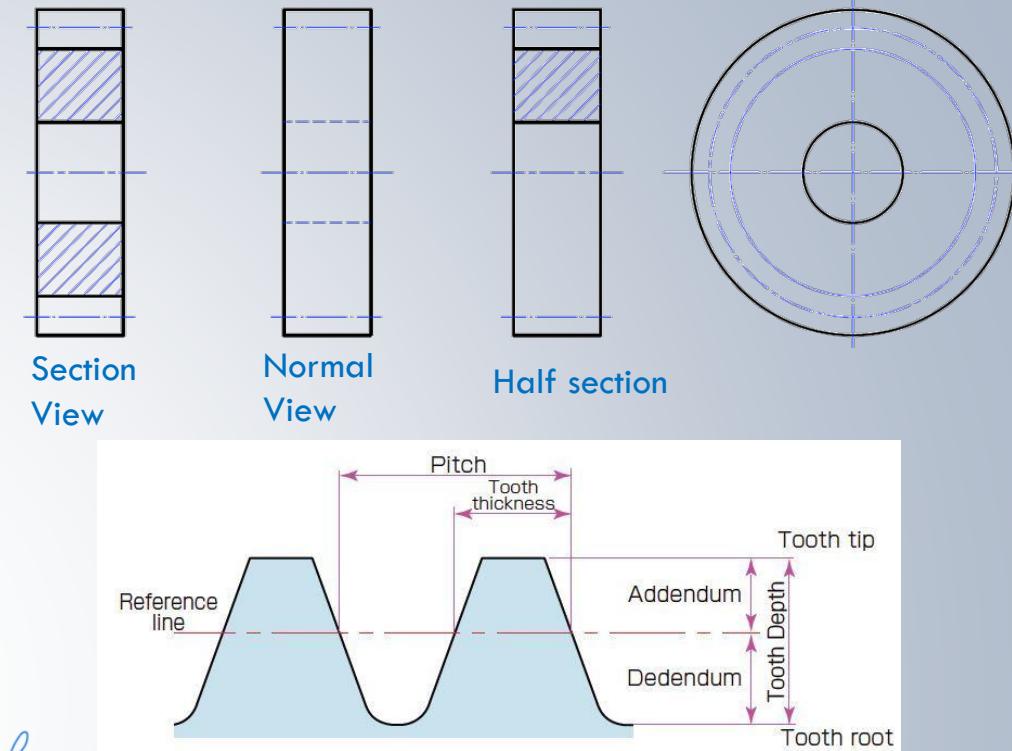
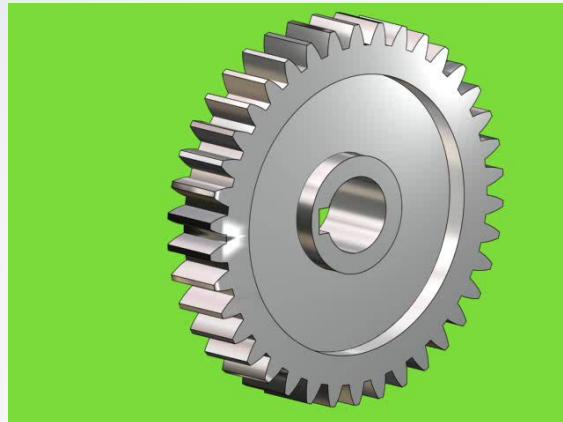
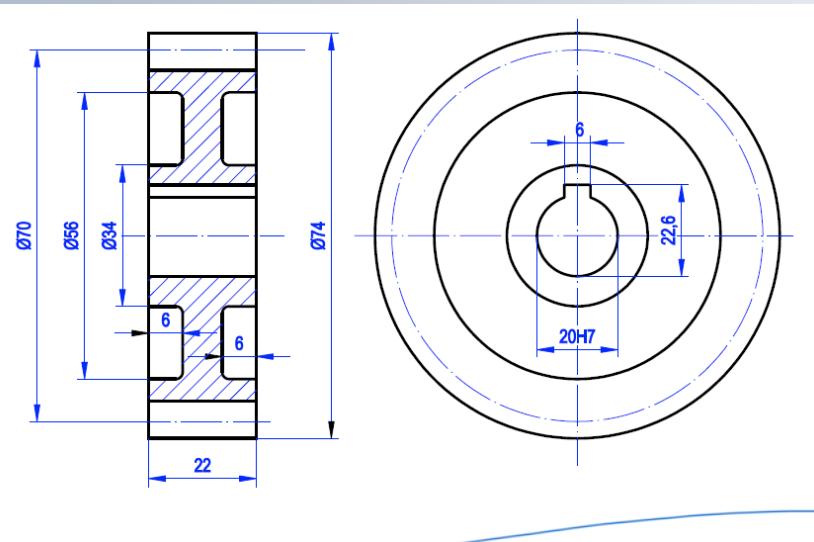
<https://www.youtube.com/watch?v=vHbQWFi7S9Y>



COUPLINGS

GEAR DRAWING

Spur gear

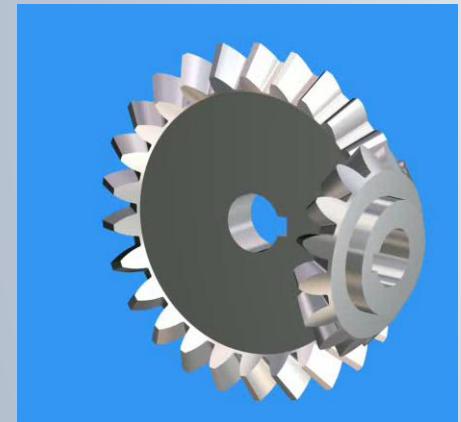


Gear Terminology

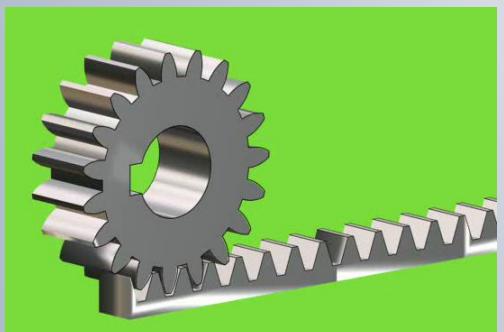
GEAR DRAWING



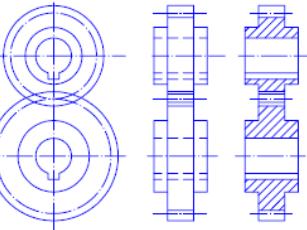
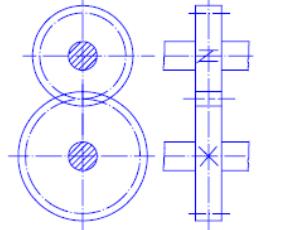
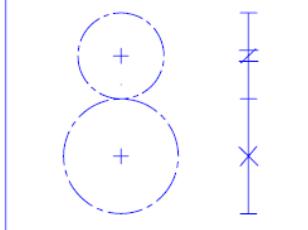
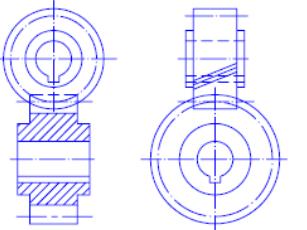
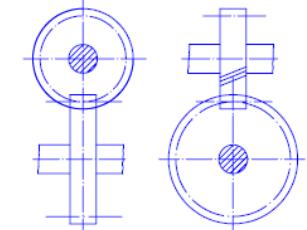
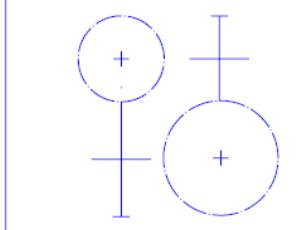
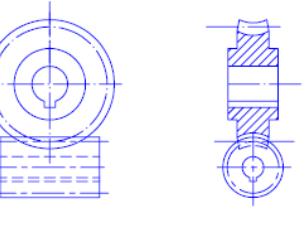
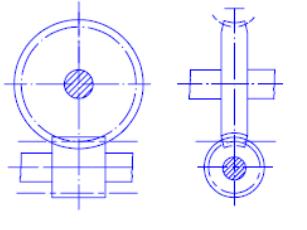
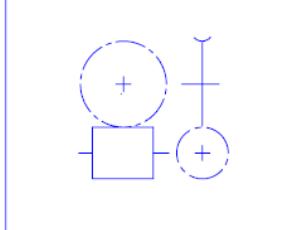
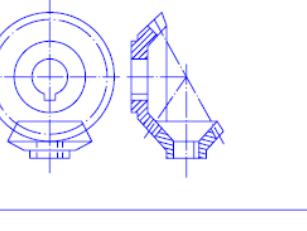
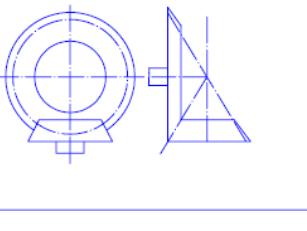
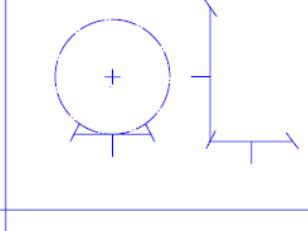
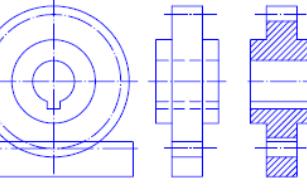
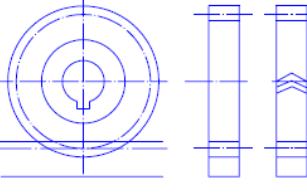
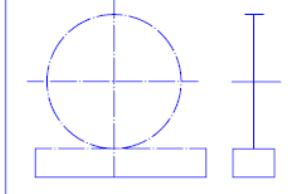
Spur Gear



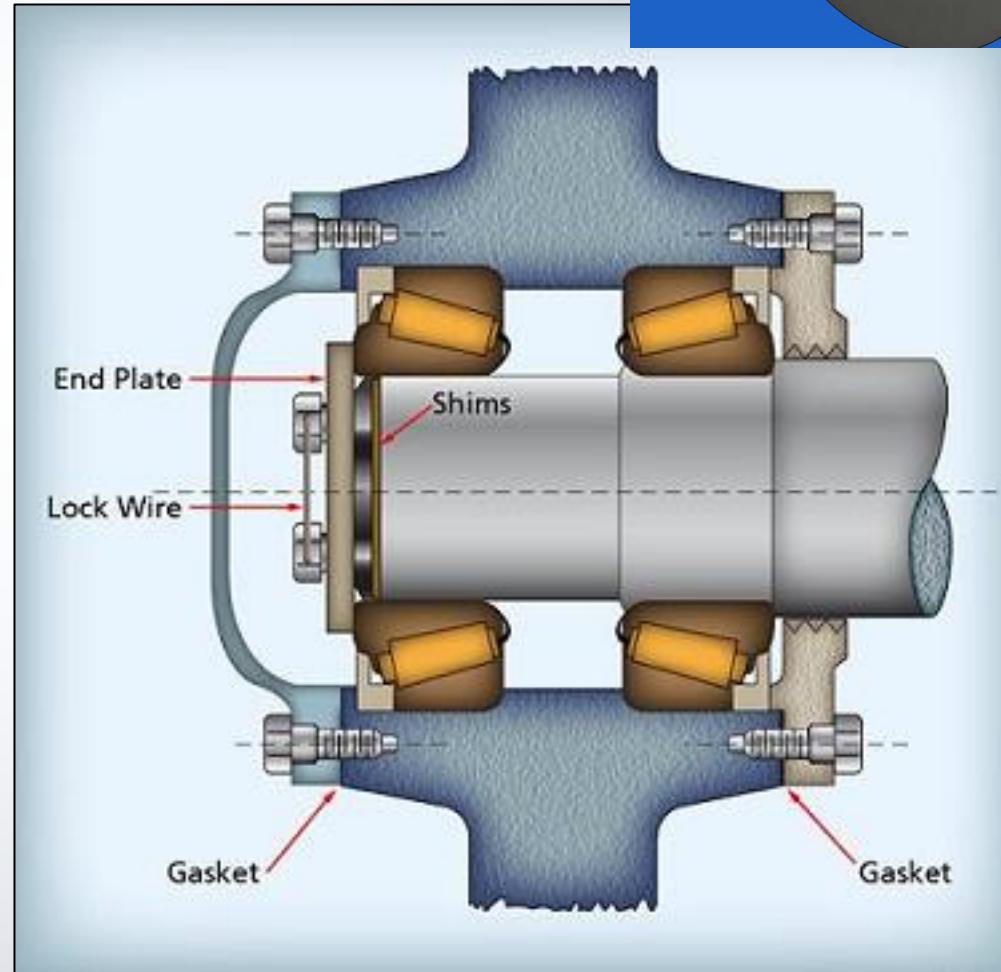
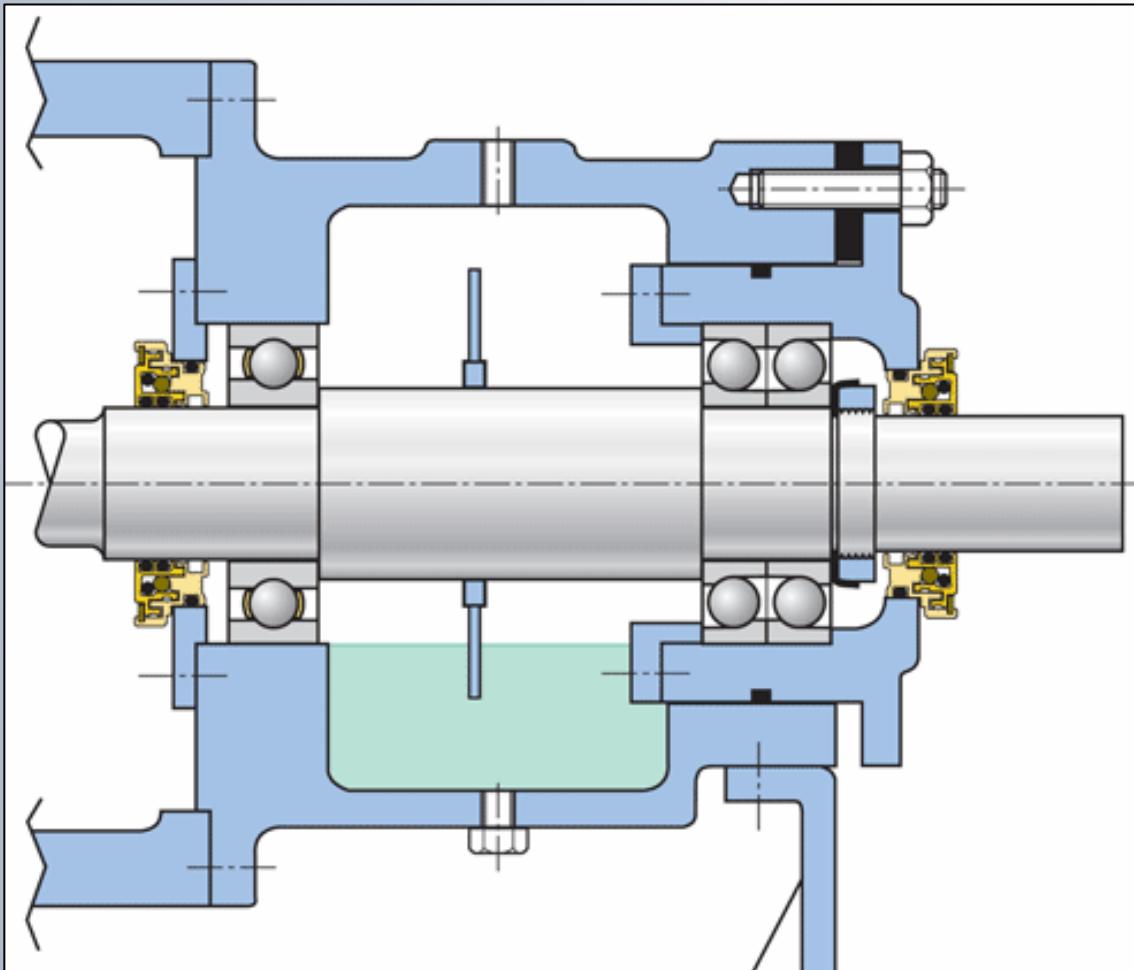
Worm Gear

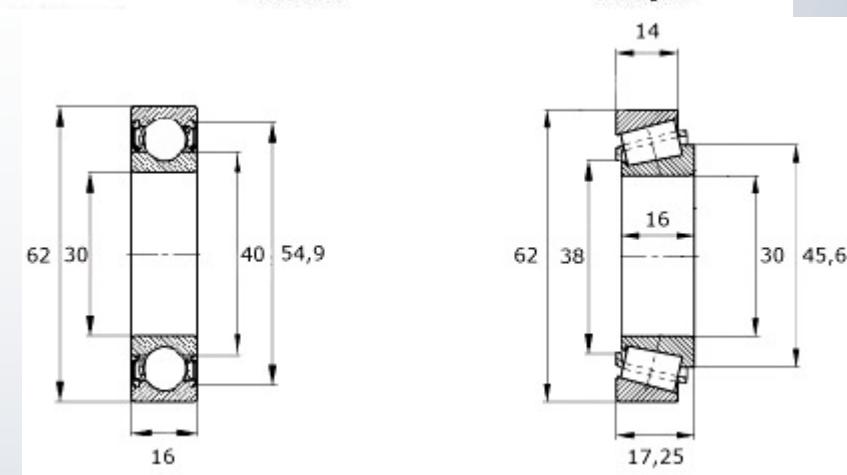
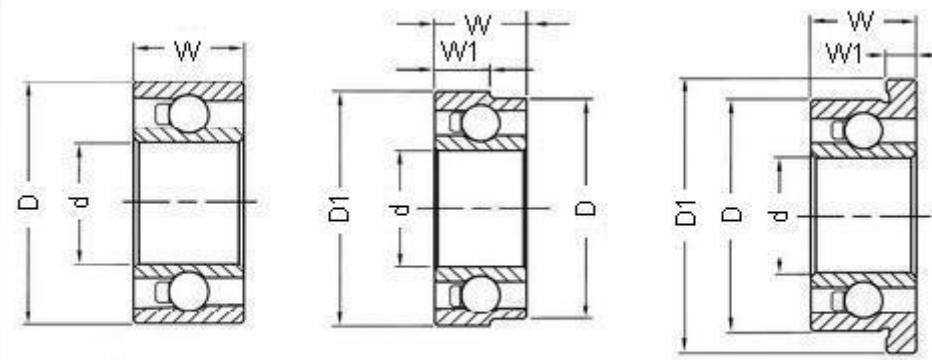
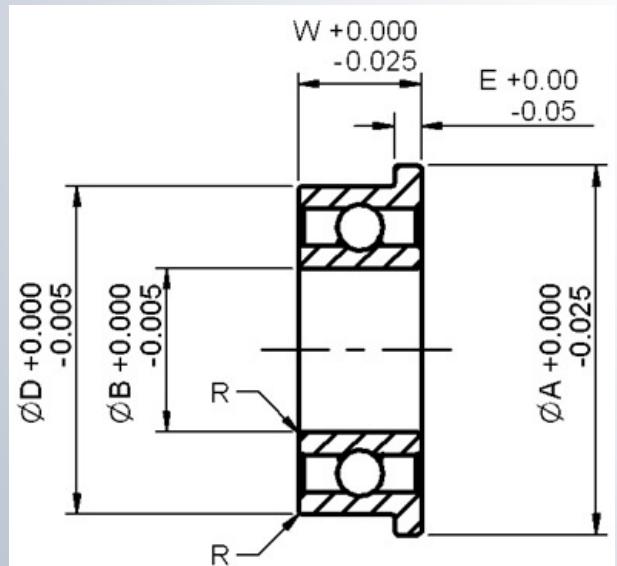
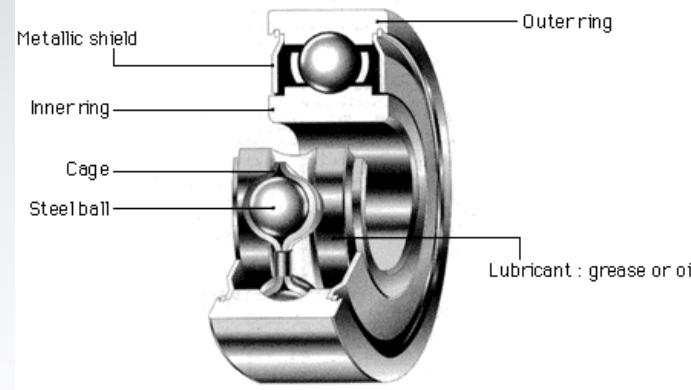
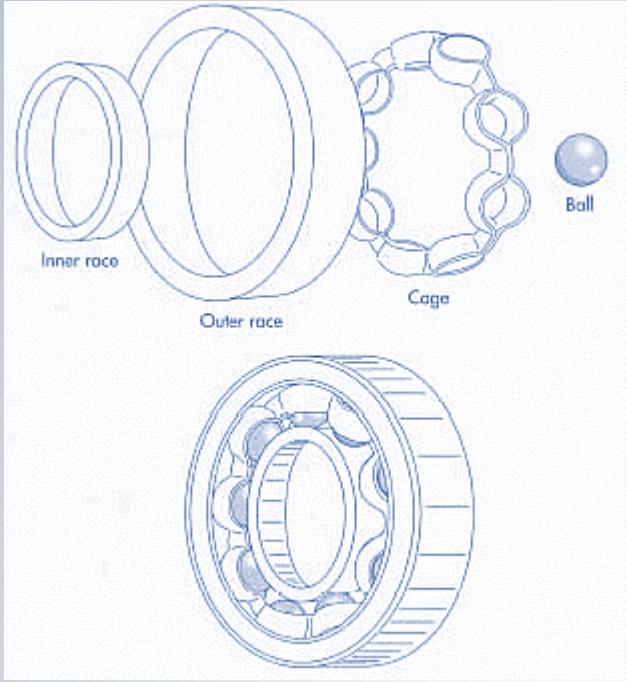


Rack Gear

normal	simple	schematic	
			
			
			
			
			

BEARING DRAWINGS





Suitability of rolling bearings for industrial applications

Symbols

+++ excellent	↔ double direction
++ good	← single direction
+ fair	□ non-locating displacement on the seat
- poor	■ non-locating displacement within the bearing
-- unsuitable	✓ yes ✗ no

Bearing type

Bearing type	Load carrying capability			Misalignment		Arrangement		Suitable for				Design features		Tapered bore	Standard housings and accessories available				
	Radial load	Axial load	Moment load	Static misalignment	Dynamic misalignment (few tenths of a degree)	Locating	Non-locating	Adjusted	Floating	Long grease life	High speed	Low run-out	High stiffness	Low friction	Integral sealing	Separable ring mounting			
Deep groove ball bearings		+	+↔	A-, B+	-	--	↔	□	✗	✓	A+++ A++ B++	A+++ B++	+	+++	A✓	✗	✗	✗	
Insert bearings		+	+↔	--	++	--	↔	↔	✗	✗	+++	++	A, B+ C++	+	++	✓	✗	✓	
Angular contact ball bearings, single row		+1)	++↔	--	-	--	✗	✗	✓	✗	++	++	+++	++	++	✓	✗	✗	
matched single row		A, B++ C++1)	A, B++↔ C++↔	A++, B+ C--	A, C--, B-	--	A, B↔ C↔	A, B□ C✗	✗	✗	++	++	+++	++	++	✗	✗	✗	
double row		++	++↔	++	--	--	↔↔	□	✗	✗	++	++	++	++	++	A✓	B✓	✗	
four-point contact		+1)	++↔	--	--	--	↔1)	--	--	--	+	+++	++	++	++	✗	✓	✗	
Self-aligning ball bearings		+	-	--	+++	+2)	↔	□	✗	✓	+++	++	++	+	+++	✓	✗	✓	
Cylindrical roller bearings, with cage		++	--	--	-	--	✗	■	✗	✗	++	+++	++	++	+++	✗	✓	✗	
		++	A, B+← C, D+↔	--	-	--	A, B← C, D↔	A, B■← C, D✗	✗	A✓ B, C, D✗	+3)	+++	++	++	+++	✗	✓	✗	
full complement, single row		+++	+↔	--	-	--	←	A, B←	✗	✓	-	+	+	+++	-	✗	A✗ B✓	✗	
full complement, double row		+++	A-, B+← C, D+↔	--	-	--	B← C, D↔	A■↔ B■↔	✗	✗	-	+	+	+++	-	D✓	✗	✗	
Needle roller bearings, with steel rings		++	--	--	A, B- C++	--	✗	■↔	✗	✗	++	++	+	++	+	A✓	✓	✗	
assemblies / drawn cups		++	A, B-- C-	--	-	--	A, B↔ C↔	A, B■ C■↔	✗	✗	++	++	+	++	+	B, C✓	✓	✗	
combined bearings		++	A-, B+ C++	--	--	--	←	✗	✓	✗	+	+	+	+	++	✗	✓	✗	
Tapered roller bearings, single row		+1)	++↔	--	-	--	←	✗	✓	✗	+	++	+++	++	+	✗	✓	✗	
matched single row		A, B+++ C++1)	A, B++↔ C++↔	A+, B++ C--	A-, B, C--	--	A, B↔ C↔	A, B□ C✗	A, B✗ C✓	✗	+	+	++	+++	+	✗	✓	✗	
double row		+++	++↔	A+, B++	A-, B--	--	↔	□	✗	✗	+	+	+	++	+++	+	✓	✓	B✓
Spherical roller bearings		+++	+↔	--	+++	+2)	↔	□	✗	✓	+	++	+++	++	+	✓	✗	✓	
CARB toroidal roller bearings, with cage		+++	--	-	++	-	✗	■	✗	✗	+	++	+++	++	+	✗	✗	✓	
full complement		+++	--	-	++	-	✗	■	✗	✗	-	+	+++	++	-	✓	✗	✓	
Thrust ball bearings		--	A+← B+↔	--	--	--	A← B↔	X	X	X	+	-	++	+	+	X	✓	✗	
with spherded housing washer		--	A+← B+↔	--	++	--	A← B↔	X	X	X	+	-	+	+	+	X	✓	✗	
Cylindrical roller thrust bearings		--	++↔	--	--	--	←	✗	✗	✗	-	-	+	+++	+	X	✓	✗	
Needle roller thrust bearings		--	++↔	--	--	--	←	✗	✗	✗	-	-	+	+++	+	X	✓	✗	
Spherical roller thrust bearings		+1)	+++↔	--	+++	+2)	↔	✗	✓	✗	-	+	+	+++	+	X	✓	✗	

[Click here for source](#)

¹⁾ Provided the F_d/F_r ratio requirement is met ²⁾ Reduced misalignment angle – contact SKF ³⁾ Depending on cage and axial load level

ROLLING BEARINGS - GENERAL SIMPLIFIED REPRESENTATION

- For general purposes (without specified load-bearing characteristics or bearing features, where it is not necessary to show the exact contour), the rolling bearing shall be represented by a square and a free-standing upright cross centered in the square (see Figure 1). The cross shall not touch the outlines.
- This representation shall be used in the space on one or both sides of the axis (see for example Figure 3, for the case of a horizontal axis).
- If it is necessary to show the exact contour of a rolling bearing, it should be represented by the true outline of its cross-section, with the upright cross in a central position (see Figure 2). The cross shall not touch the outlines.

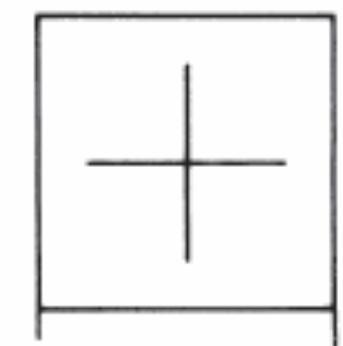


Figure 1

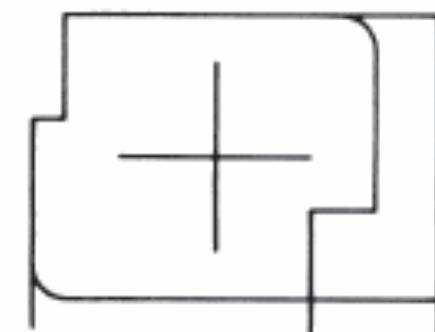


Figure 2

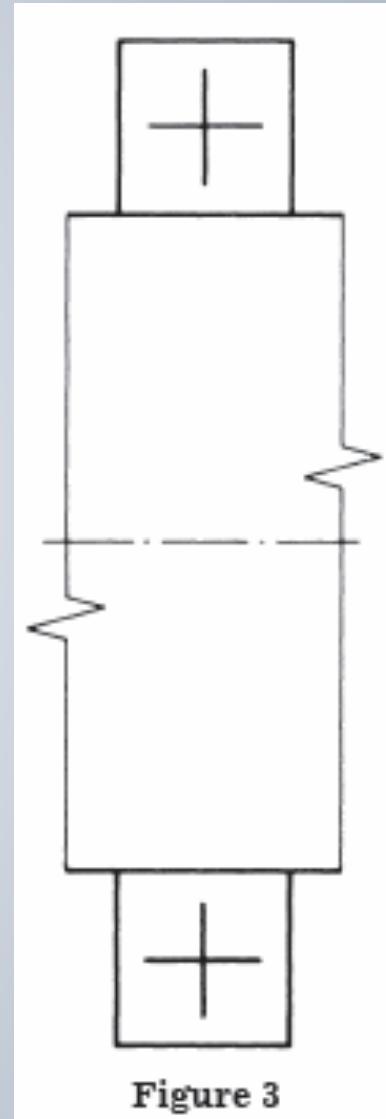


Figure 3

In representations perpendicular to the bearing axis, the rolling element may be shown as a circle, regardless of its actual shape (ball, roller, needle, etc.) and size (see Figure 1).

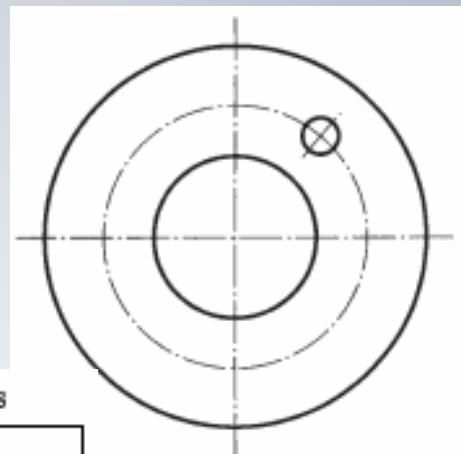


Figure 1

Table 1 — Elements of detailed simplified representation for rolling bearing features

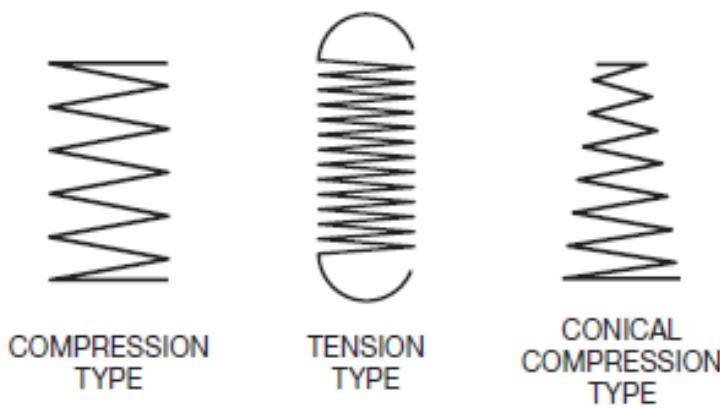
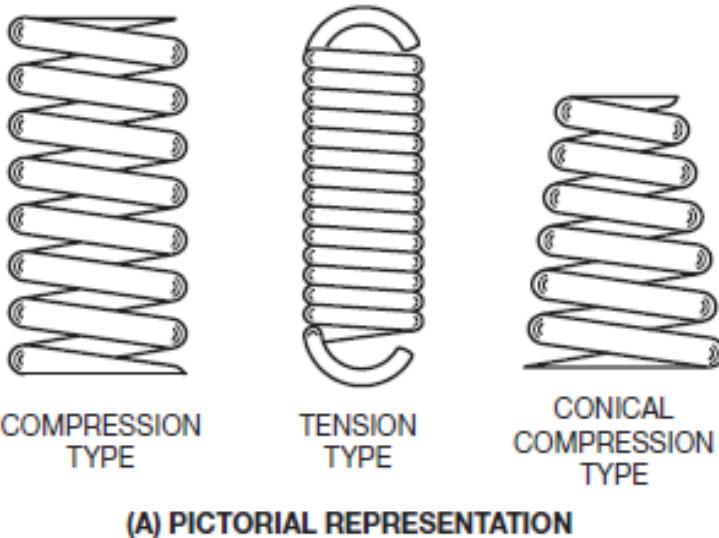
No.	Element	Description	Application
1.1	— ¹⁾	Long continuous straight line	Line representing the axis of the rolling element, without possibility of alignment
1.2	⌒ ¹⁾	Long continuous arc of circle	Line representing the axis of the rolling element, with possibility if alignment
1.3	Alternative indication (examples) ○ ²⁾ □ ²⁾ — ²⁾	Short continuous straight line, crossing the long continuous line No. 1.1 or 1.2 at 90° (preferred simplified indication) co-incident with the centreline (radial) of each rolling element. circle Wide rectangle narrow rectangle	Number of rows and position of the rolling elements ball roller needle-roller, pin
<small>¹⁾ This element may be shown inclined, depending on the type of the bearing. ²⁾ Instead of the short continuous straight line, this variation may be used to represent the rolling element.</small>			

Table 2 — Combination of elements in detailed simplified representation

Load-bearing characteristics		Bearing features			
		Two rings		Three rings	
Direction of load	Radial	One row	Two rows	One row	Two rows
		Alignment no	Alignment yes	Alignment no	Alignment yes
Radial and axial	Axial	(+)	(+)	(+)	(+)
		(+)	(+)	(+)	(+)
Radial and axial	Axial	(+)	(+)	(+)	(+)
		(+)	(+)	(+)	(+)
Radial and axial	Axial	(+)	(+)	(+)	(+)
		(+)	(+)	(+)	(+)

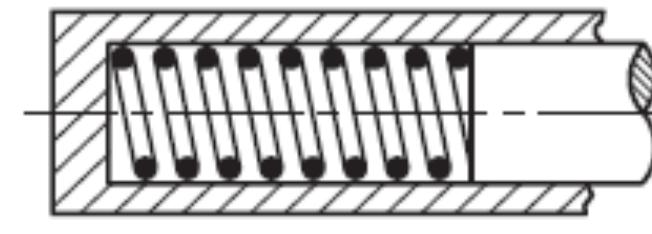
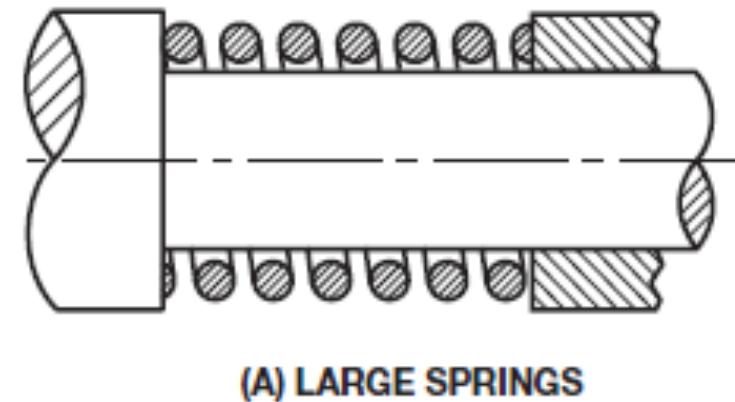
SPRINGS

FIGURE 27-4 Helical springs.



(B) SCHEMATIC OR SIMPLIFIED REPRESENTATION

FIGURE 27-5 Showing helical springs on assembly drawings

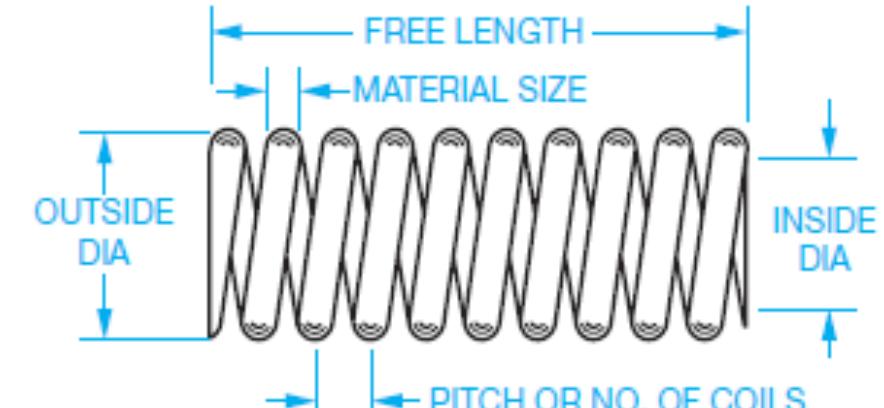


SPRINGS

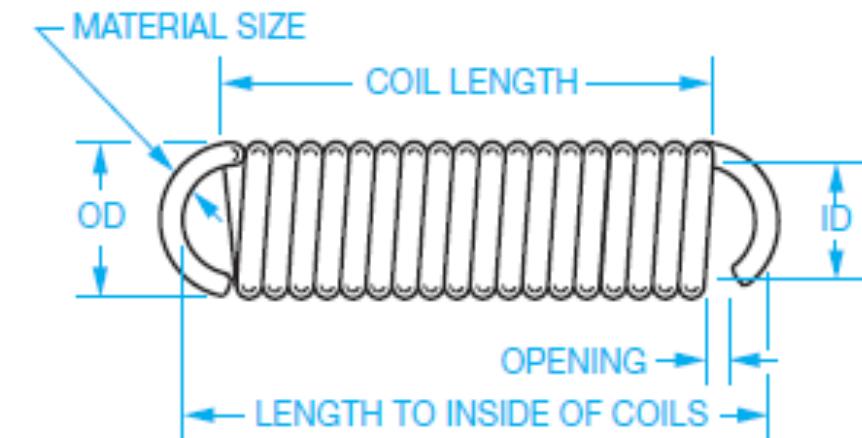
- Size, shape, and type of material used in the spring
- Diameter (outside or inside)
- Pitch or number of coils
- Shape of ends
- Length



FIGURE 27–6 Information given on spring drawings.



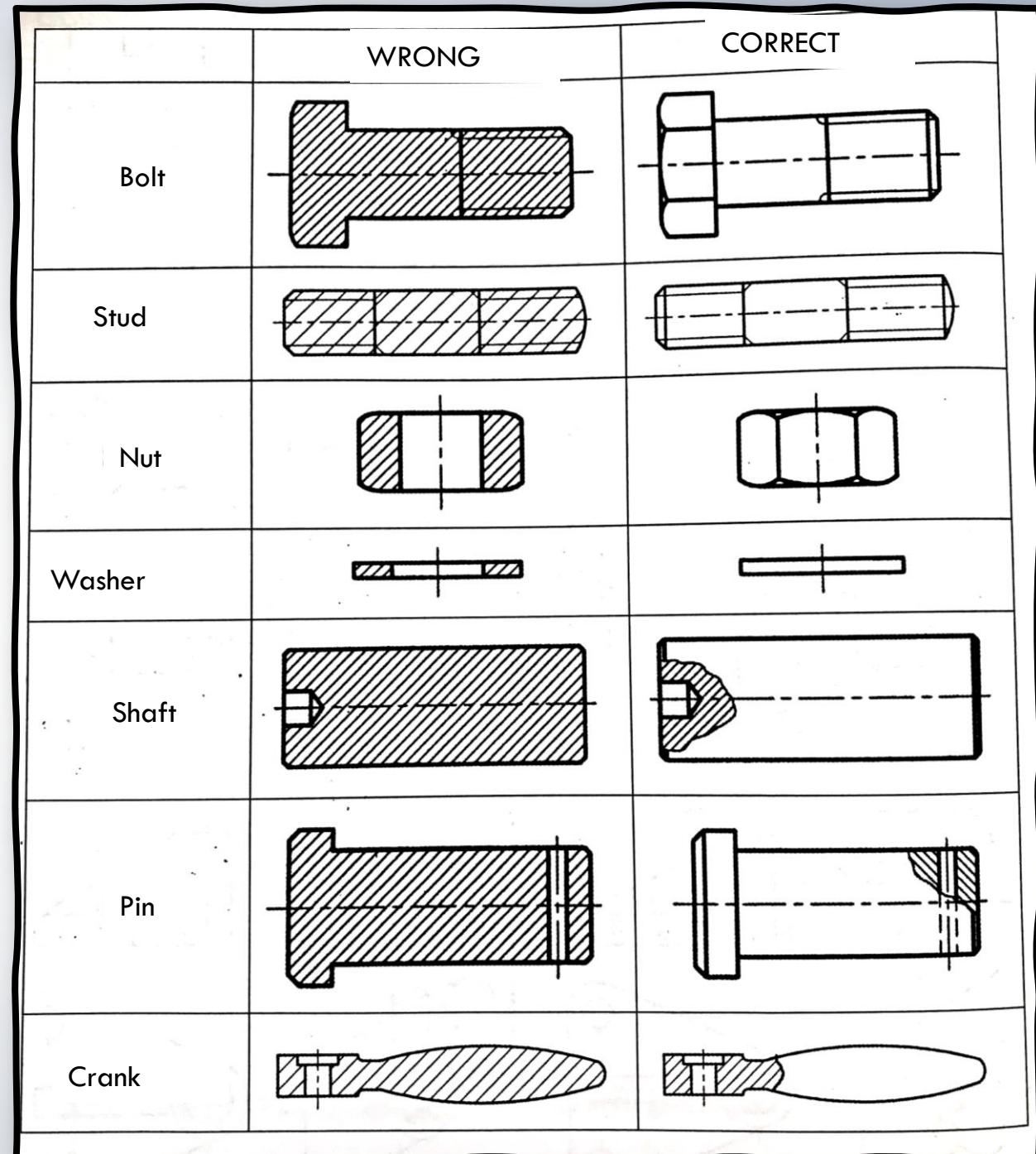
EXAMPLE 1



EXAMPLE 2

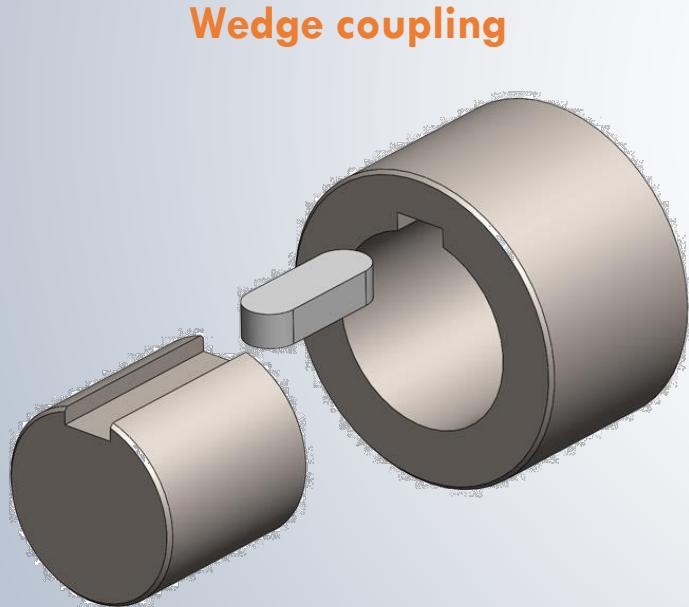
MACHINE ELEMENTS

Longitudinal section views

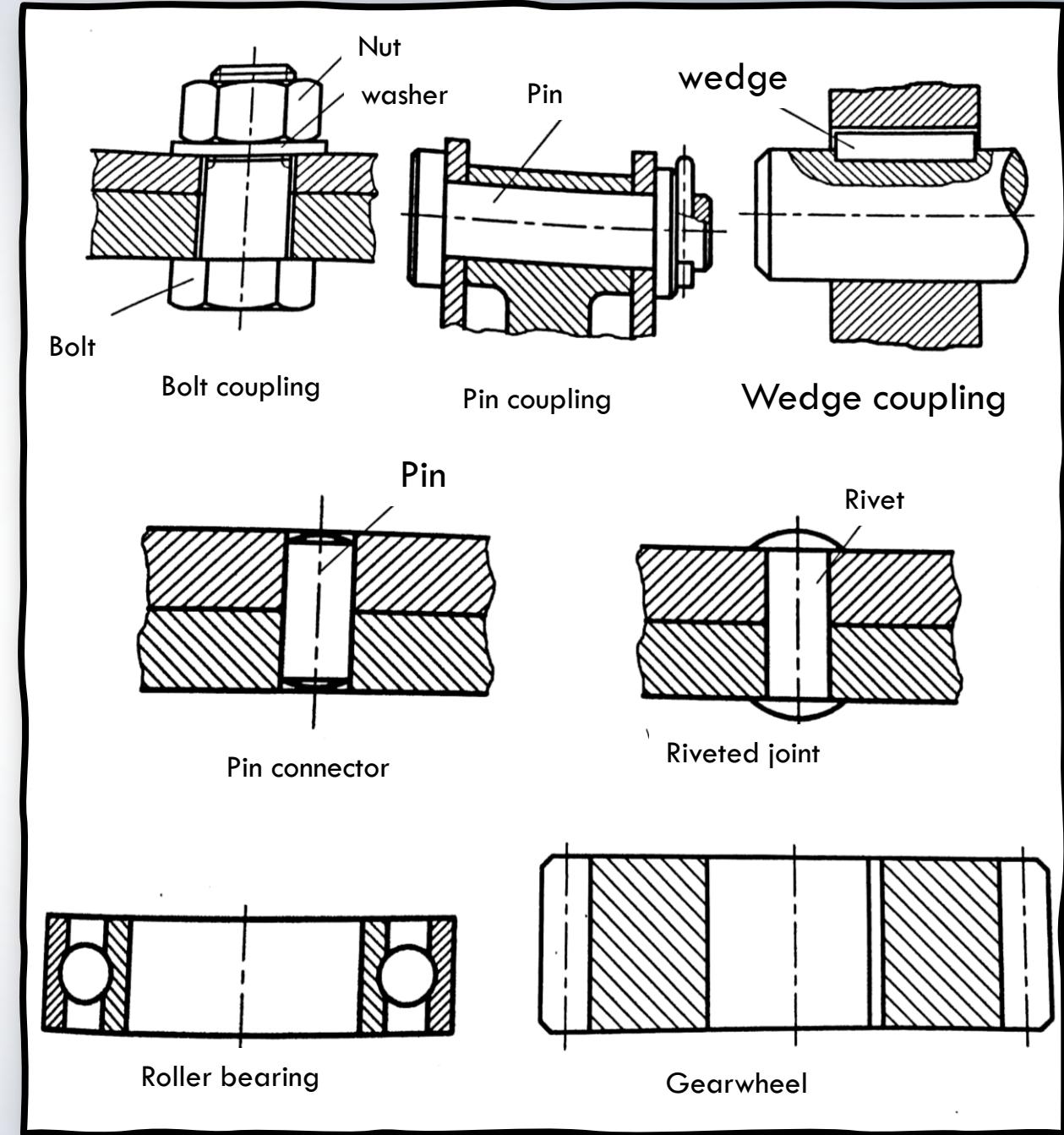


MACHINE ELEMENTS

Longitudinal section views



Wedge coupling



EXAMPLE

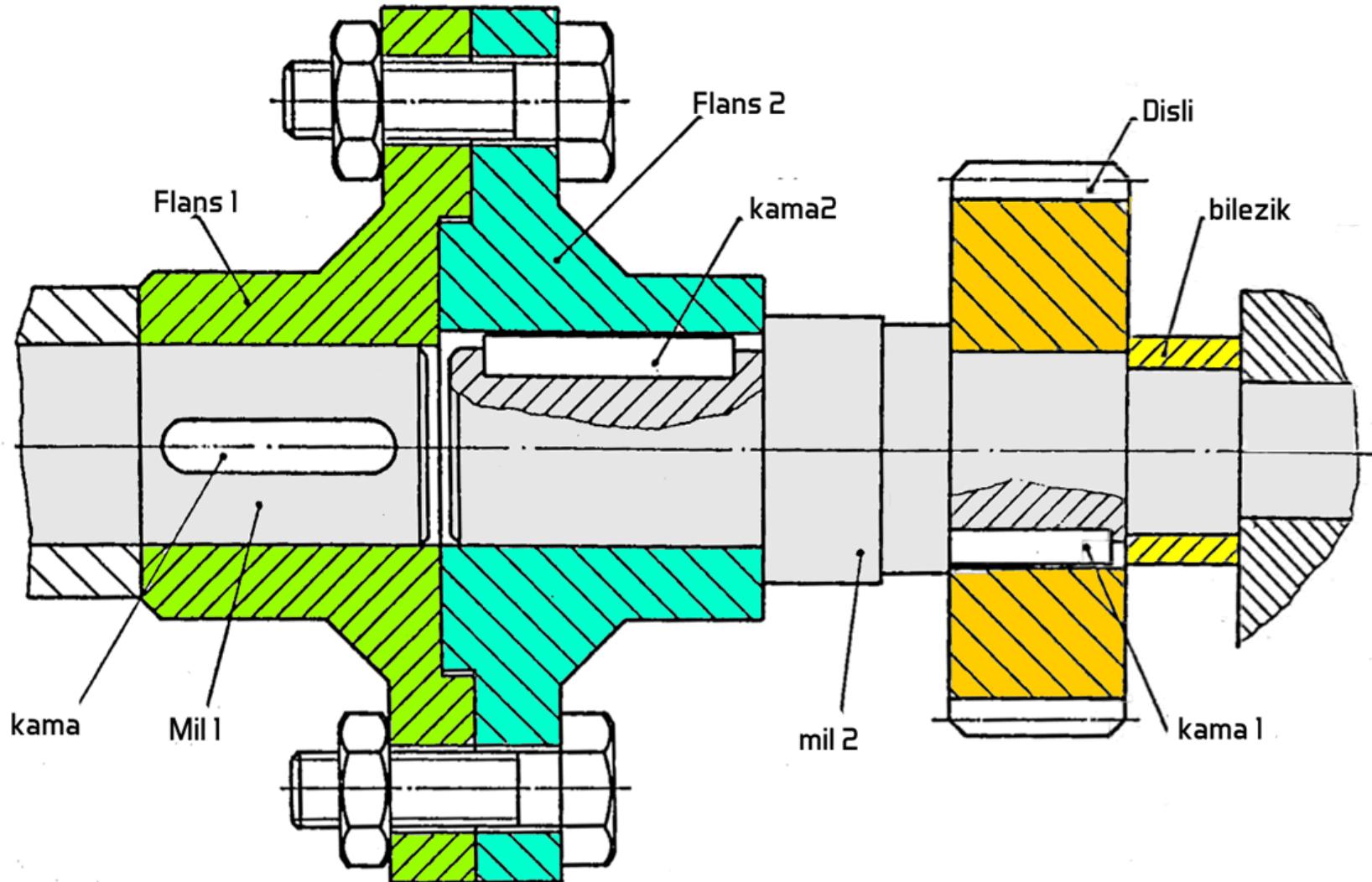
Kama: wedge

Mil: shaft

Flans: flange

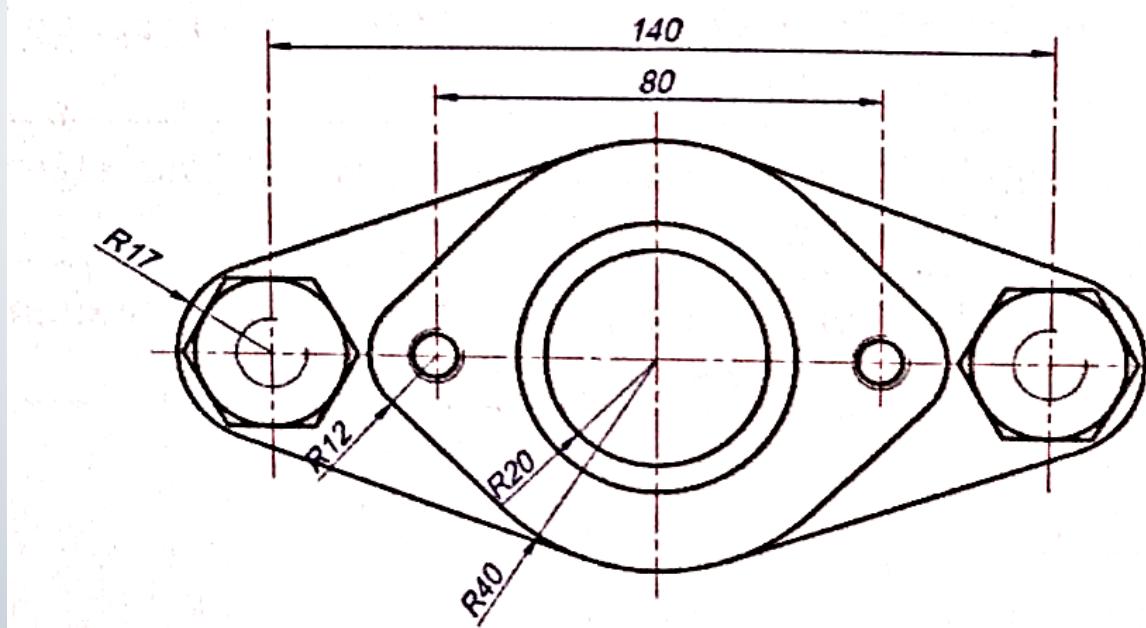
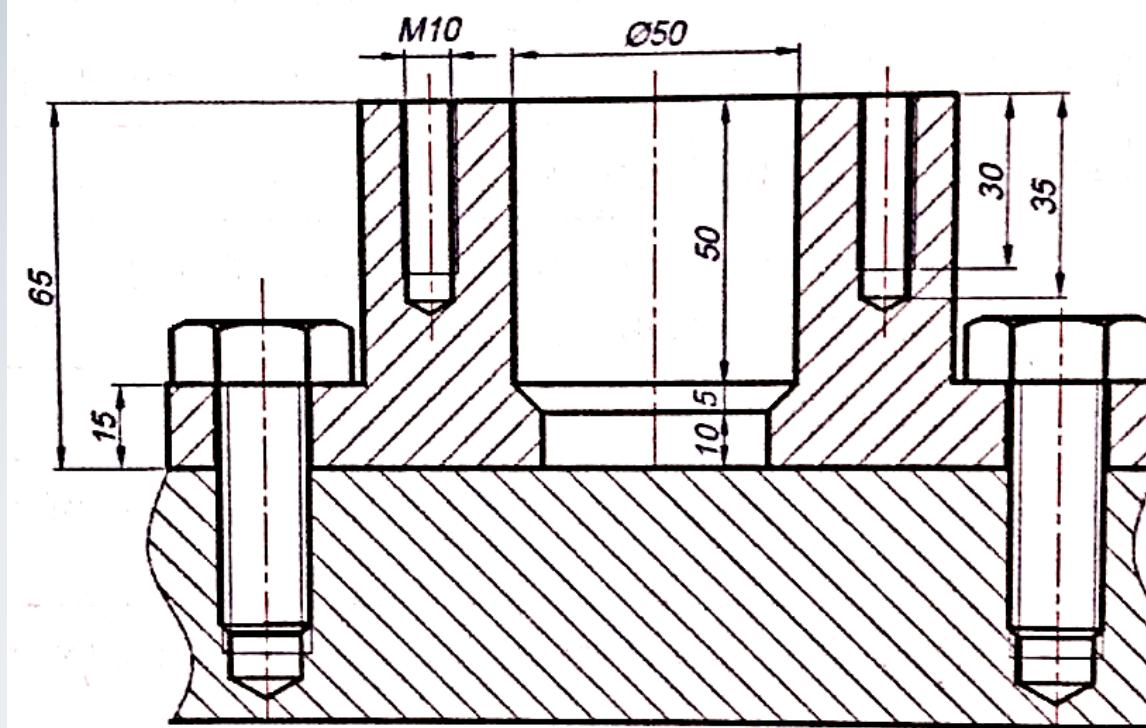
Bilezik: bush

Disli: gear



PRACTICE

$L=b=45$ mm
2 x M16 hex bolt



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