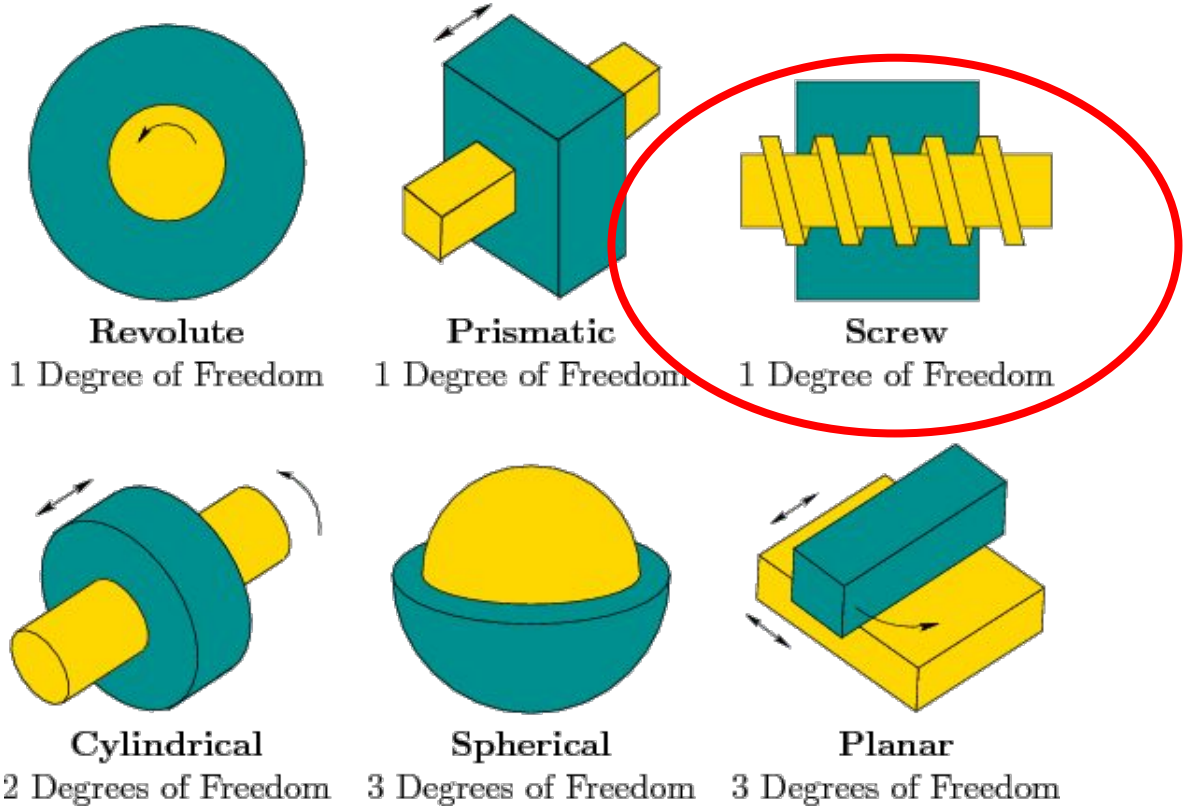
Introduction to Robotics

Lecture 2

Types of Kinematic Pairs - Lower Pairs



Steps...

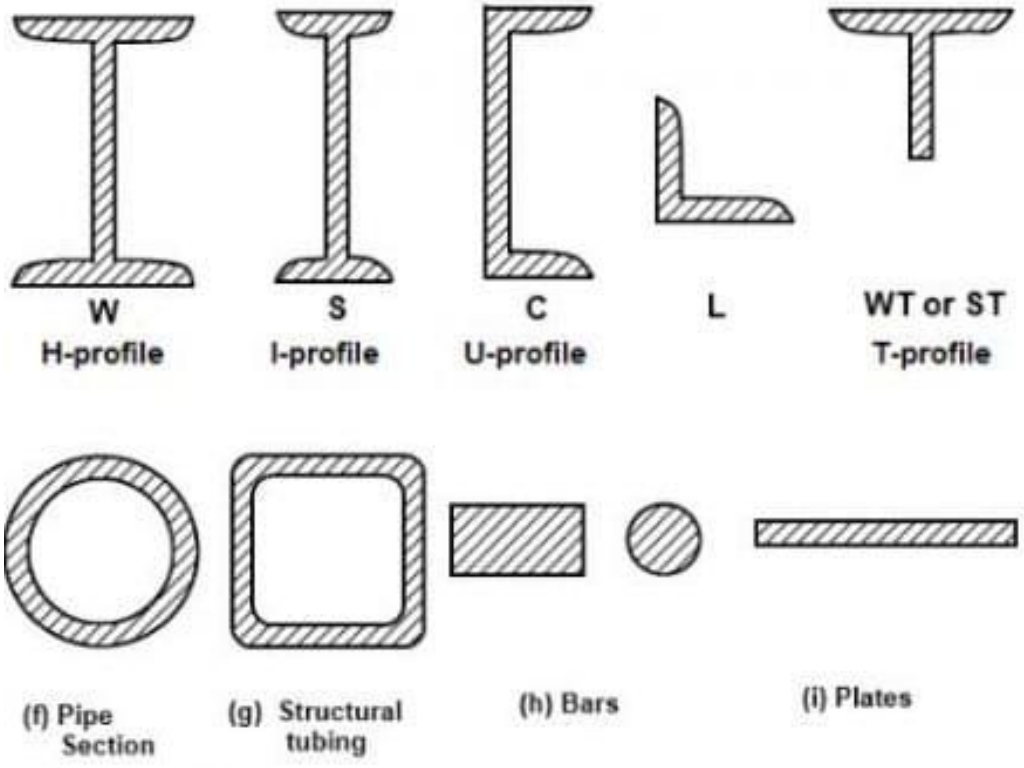
1. Identification of Problem Statement
2. Design and Calculations of the parts to be made
3. Manufacturing of Parts
4. Selection of Mechanical Components
5. Final Assembly
6. Testing
7. Repeat

Mechanical Components

Some “components” of assembly

- Members
  - Beams
  - Sections
- Shafts
- Bearings
- Gears
- Springs
- Couplings

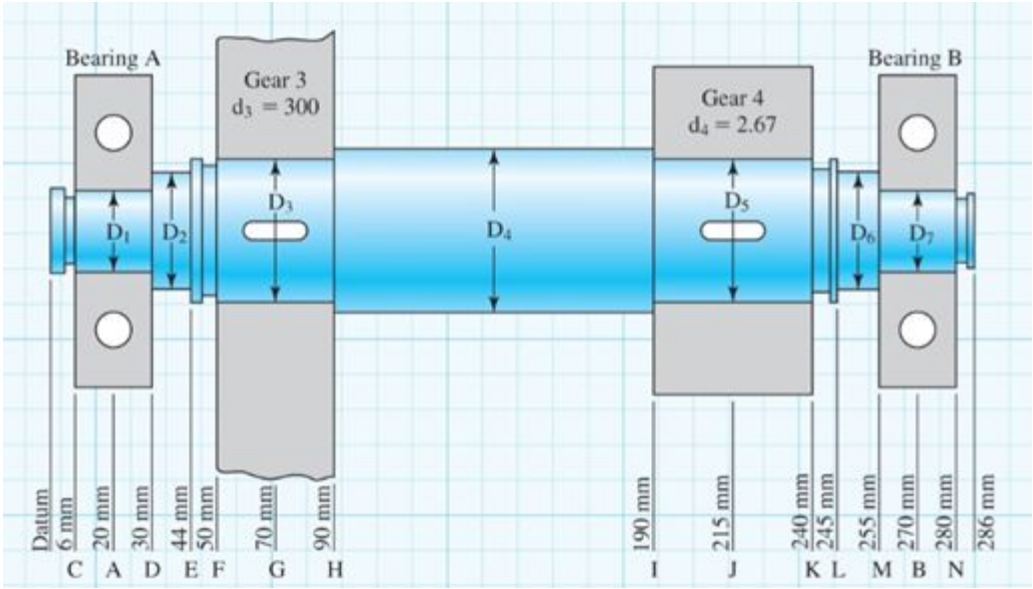
Members - Beams



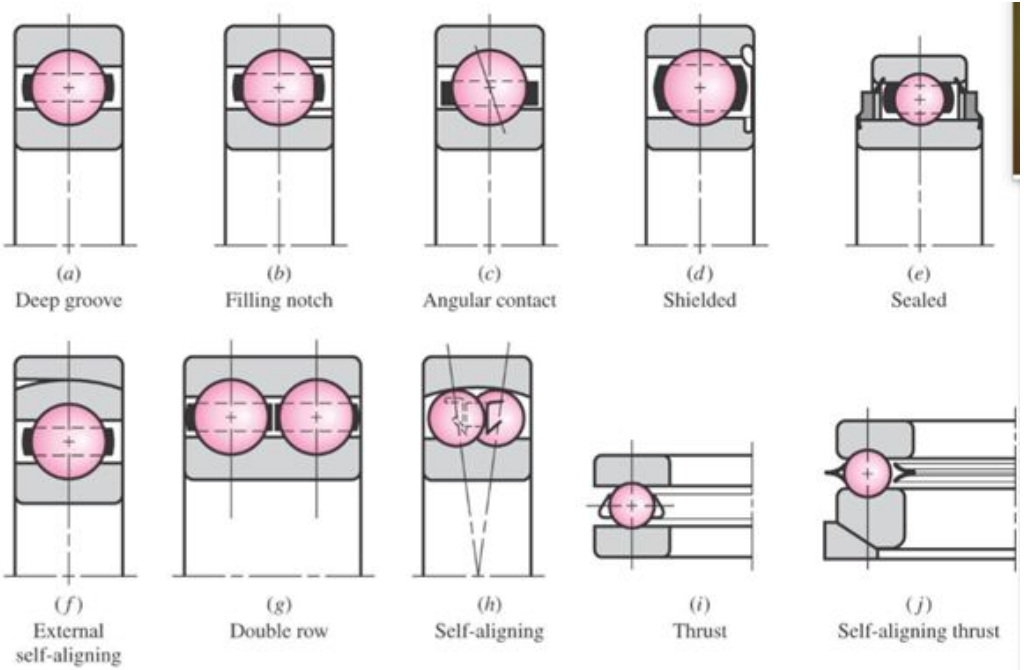
Members - Sections

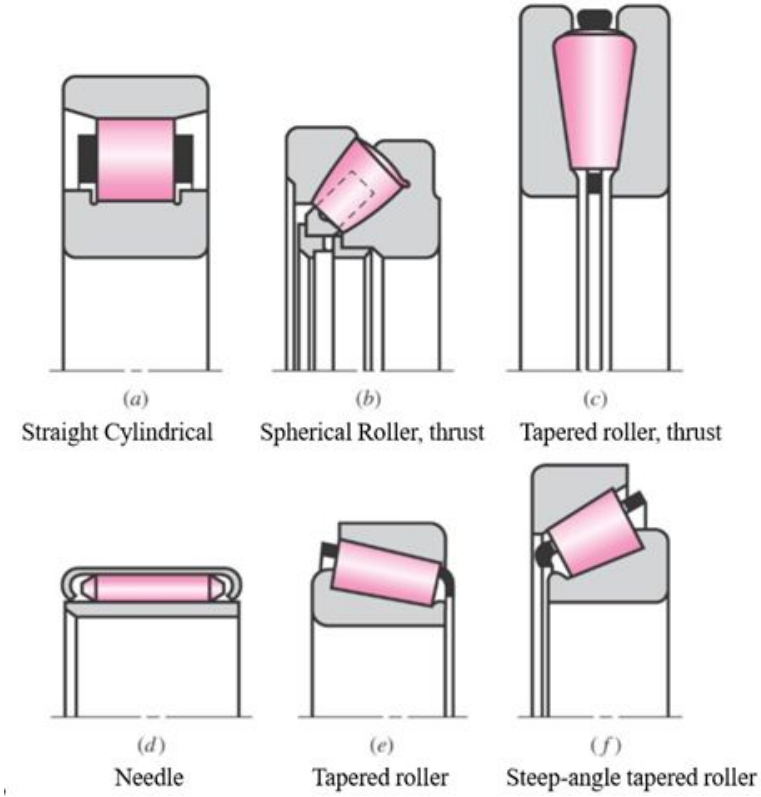
Shafts

- Rotating members, used to transmit power and/or motion.
- Acts as the axis of rotation for components like Pulleys, Gears, Bearings, Flywheels, Sprockets, etc.

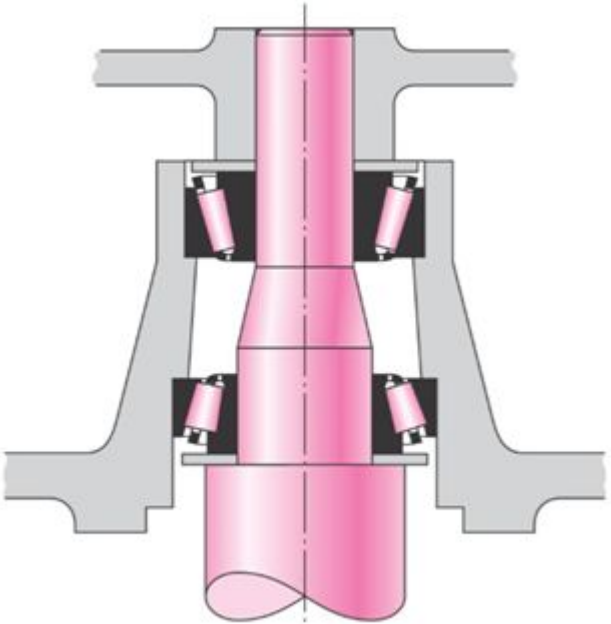


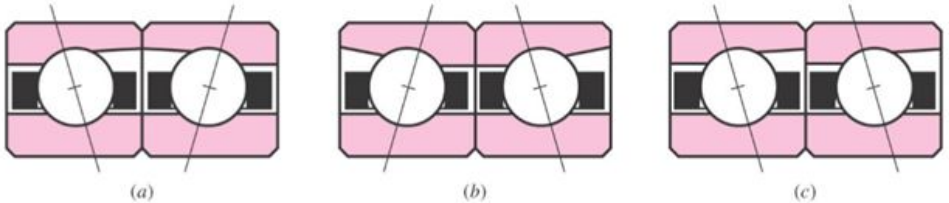
Bearings


(a)
Deep groove
(b)
Filling notch
(c)
Angular contact
(d)
Shielded
(e)
Sealed
(f)
External
self-aligning
(g)
Double row
(h)
Self-aligning
(i)
Thrust
(j)
Self-aligning thrust

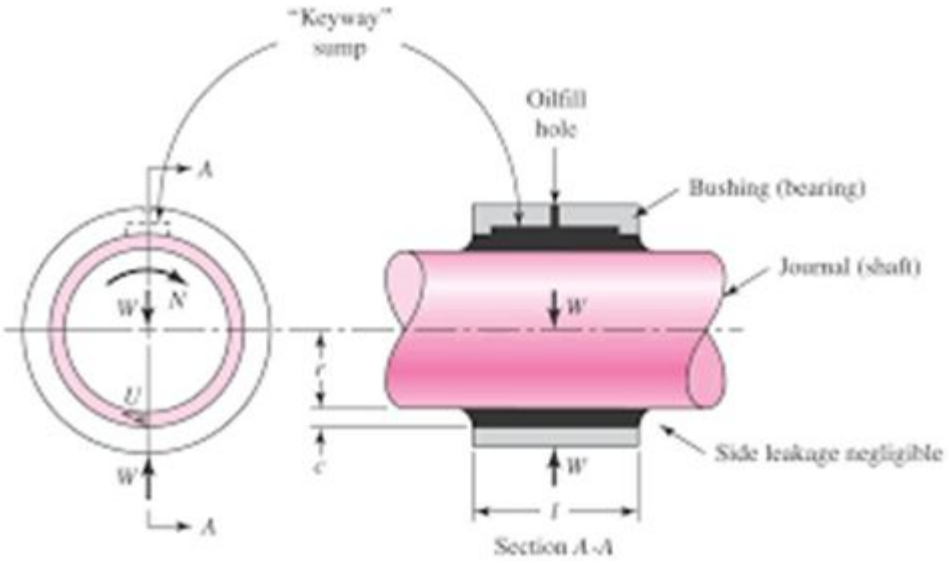

(a)
Straight Cylindrical
(b)
Spherical Roller, thrust
(c)
Tapered roller, thrust
(d)
Needle
(e)
Tapered roller
(f)
Steep-angle tapered roller

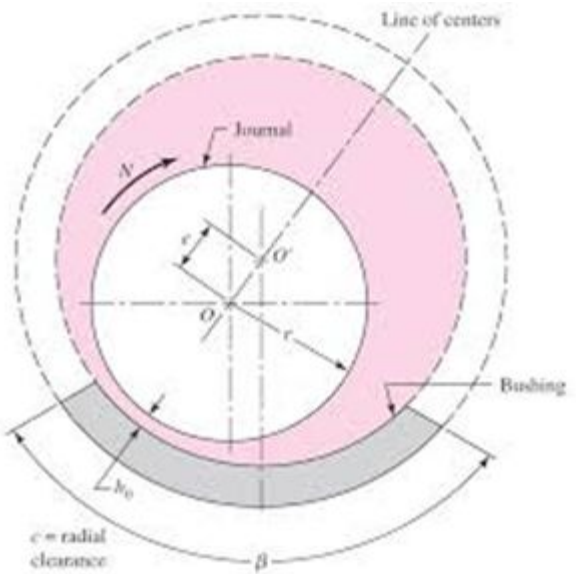
Combination of Bearings





Journal Bearings

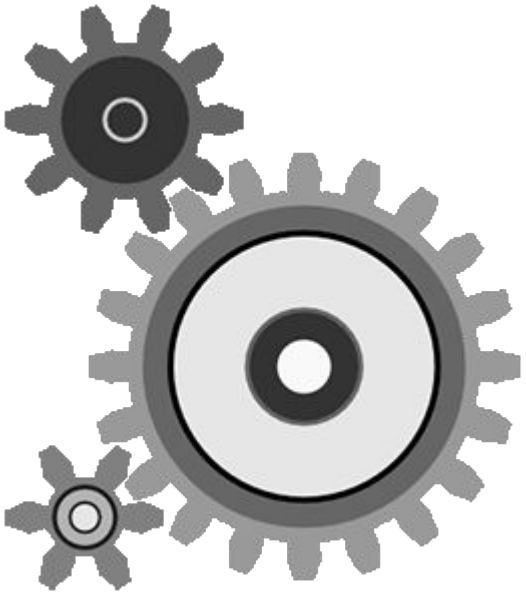




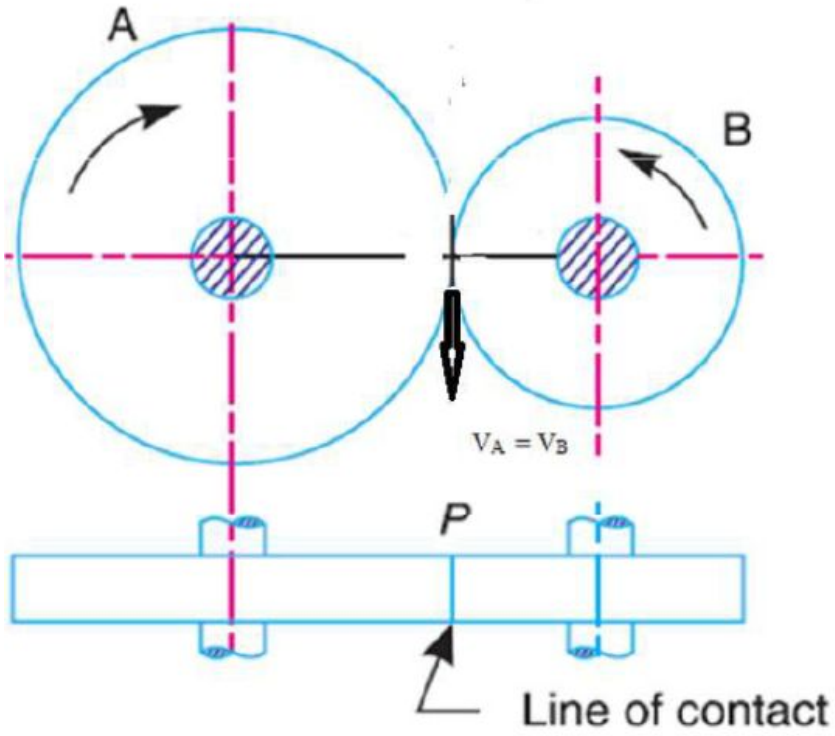
Gears

- Toothed elements used for transmission of rotary motion from one shaft to another.
- Used to convert an electric motor’s high speed low torque to low speed high torque.

- Gears do not depend on friction unlike belt drives.



Transmission of Power



$$V_1 = V_2$$

$$\omega_1 r_1 = \omega_2 r_2$$

$$\frac{2\pi N_1}{60} r_1 = \frac{2\pi N_2}{60} r_2$$

$$\frac{N_1}{N_2} = \frac{r_2}{r_1} \text{ or } \left(\frac{d_2}{d_1} \right)$$

Advantages and Disadvantages

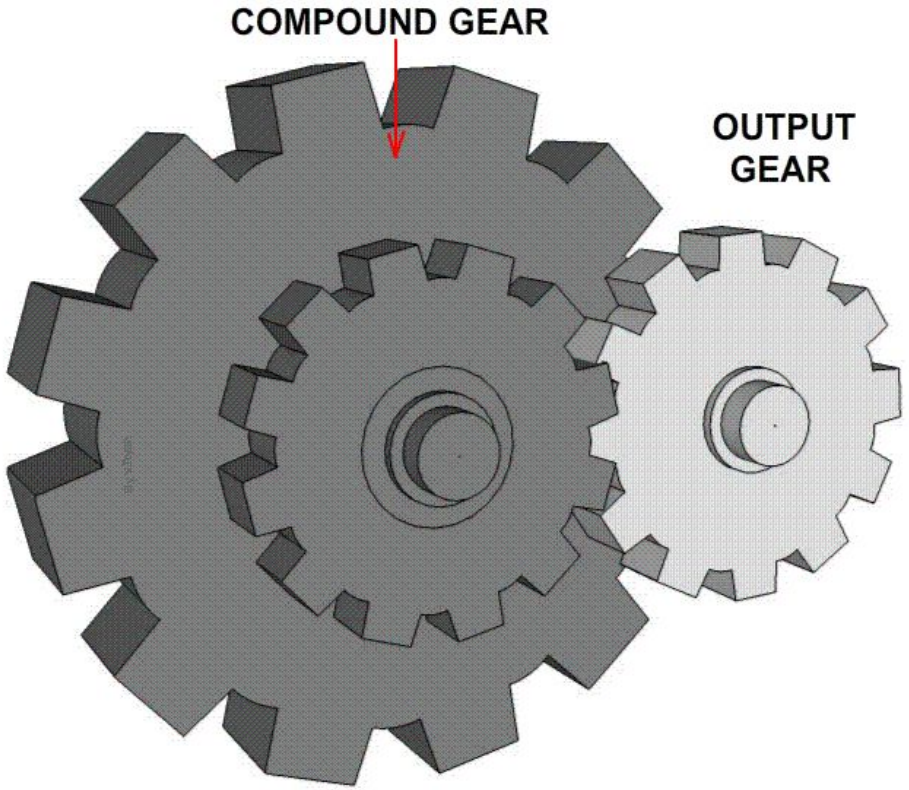
- Transmits exact velocity ratios
- Can be used to transmit large power
- High efficiency
- Reliable service
- Compact layout

- Manufacture requires special tools and equipments
- Error in cutting teeth may cause noise and vibrations during operation

Types of Gears

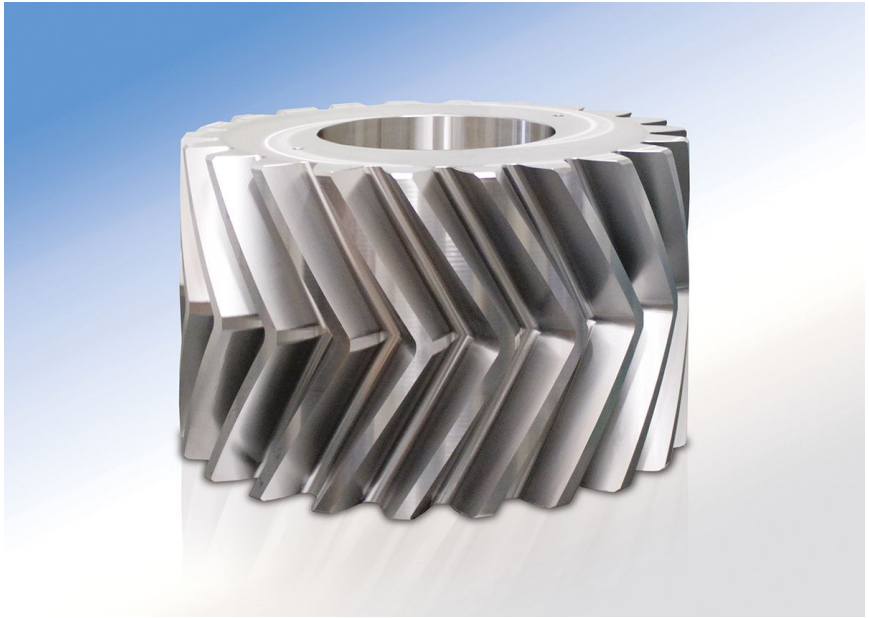
- Spur gears
- Helical gears
- Herringbone gears
- Rack and Pinion
- Bevel gears
- Worm gears
- Internal gears
- Planetary gears

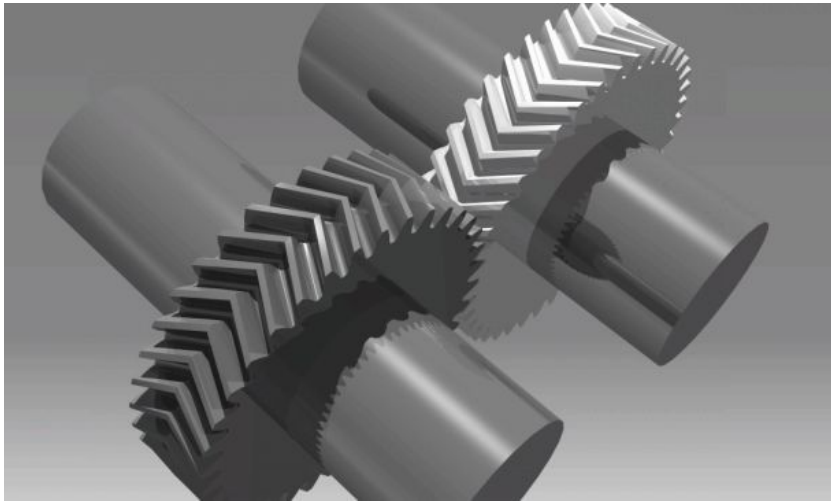
Spur Gears



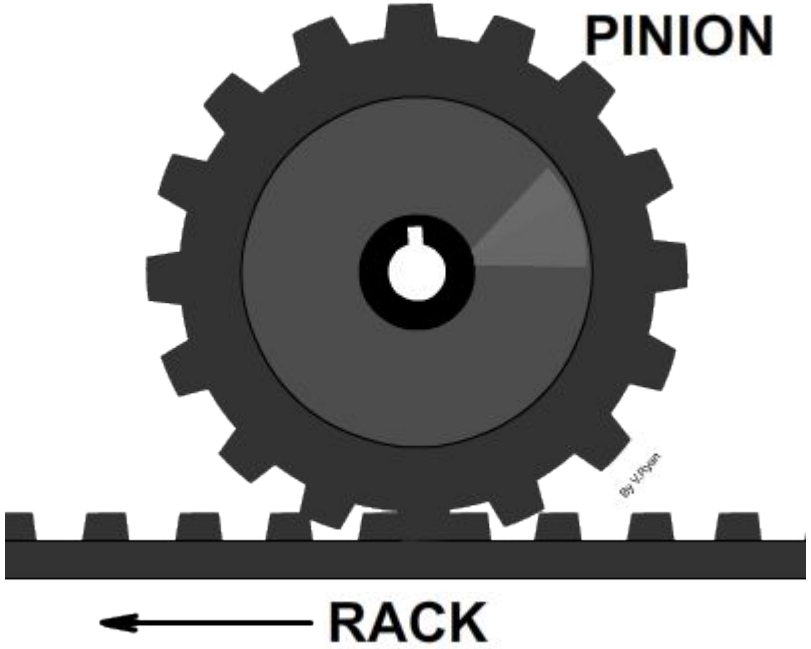
Helical gears

Herringbone gears



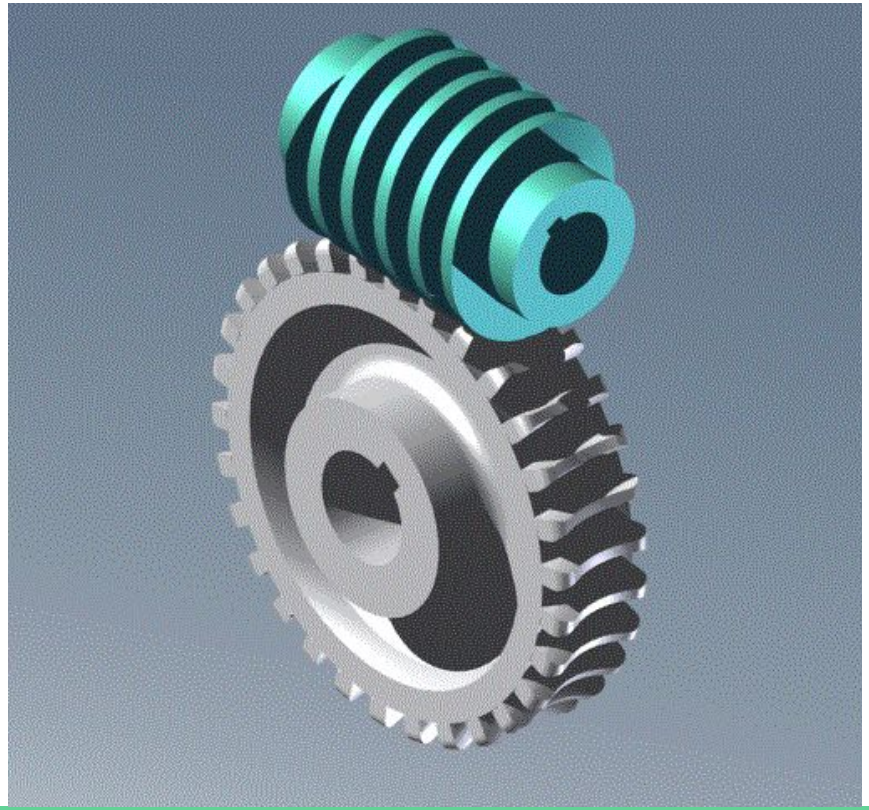


Rack and Pinion



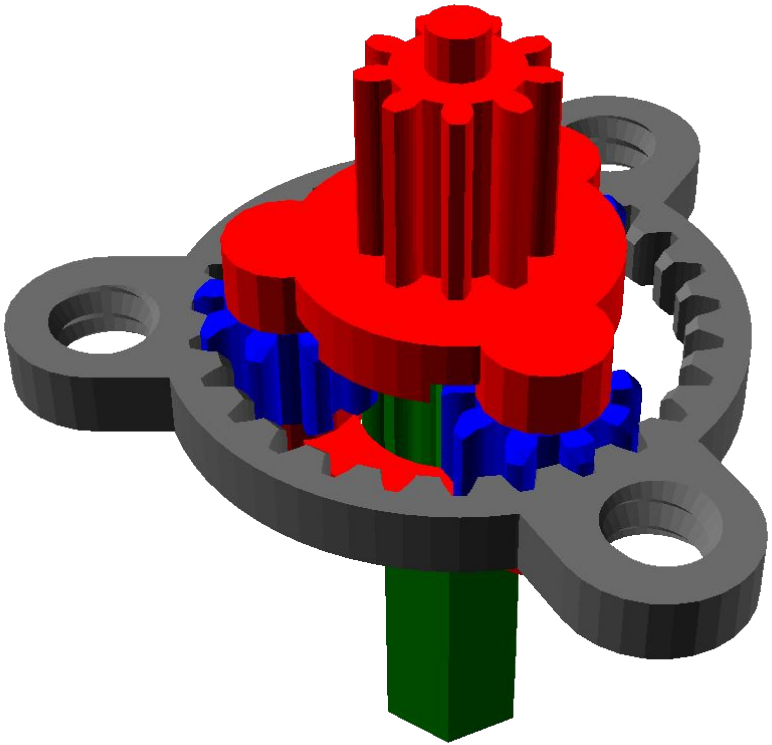
Bevel gears

Worm Gears



Internal gears

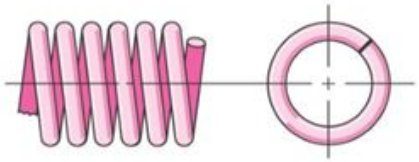
Planetary gears



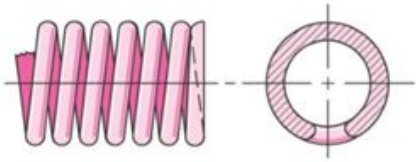
Springs


COMPRESSION
EXTENSION
TORSION
CONICAL
BARREL
MAGAZINE
GARTER
WIRE RINGS

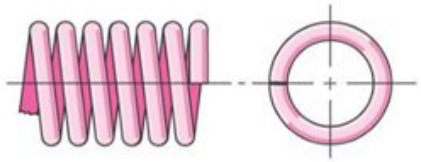
Leaf Spring



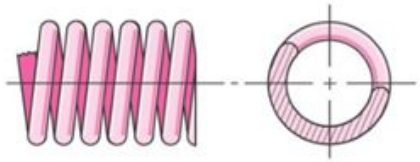
(*a*) Plain end, right hand



(*c*) Squared and ground end, left hand

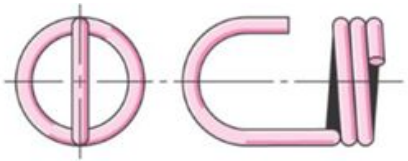


(*b*) Squared or closed end, right hand

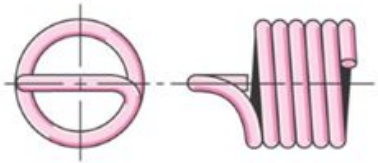


(*d*) Plain end, ground, left hand

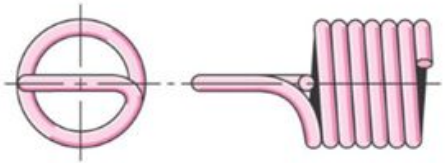
(*a*) Machine half loop–open



(*b*) Raised hook

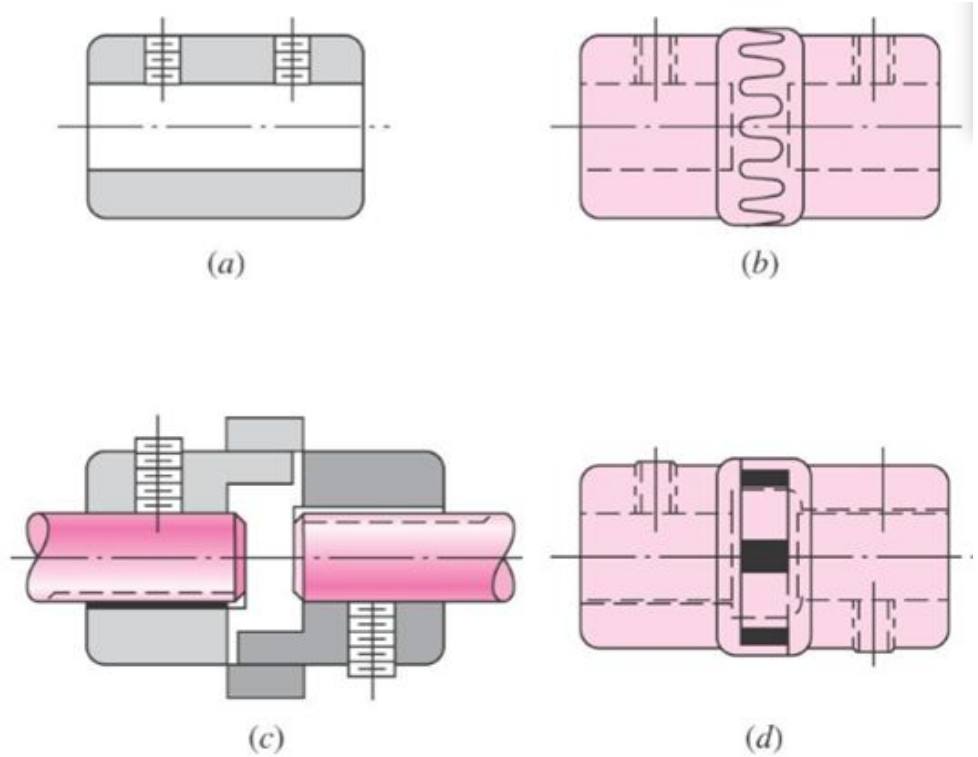


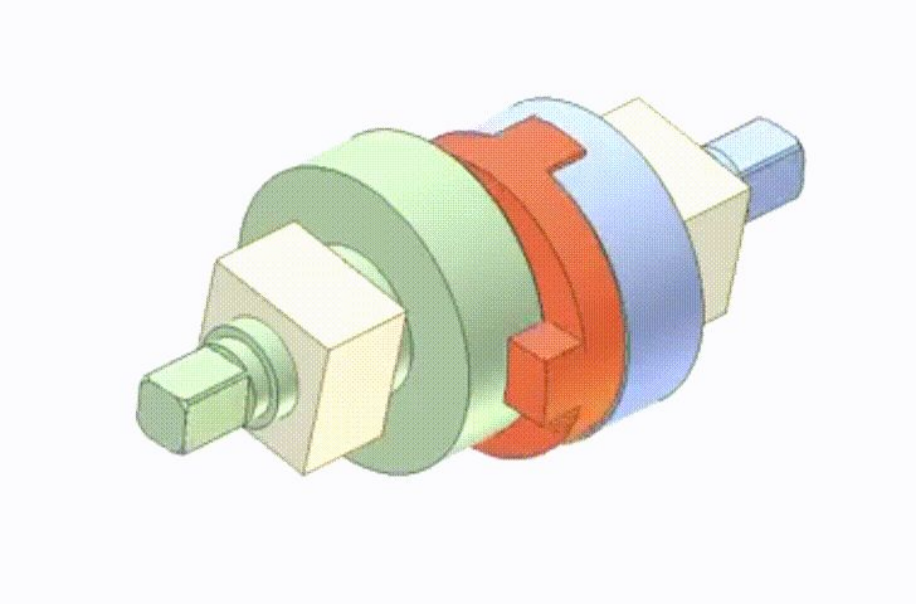
(*c*) Short twisted loop

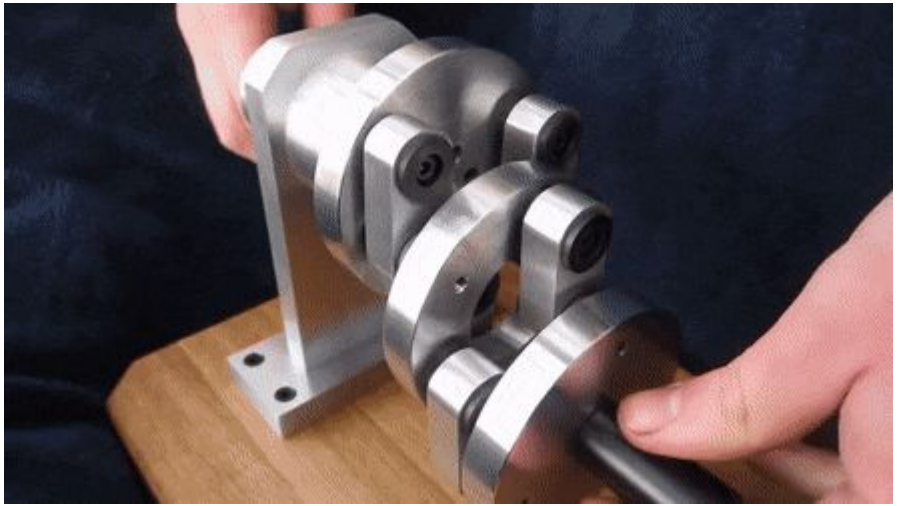


(*d*) Full twisted loop

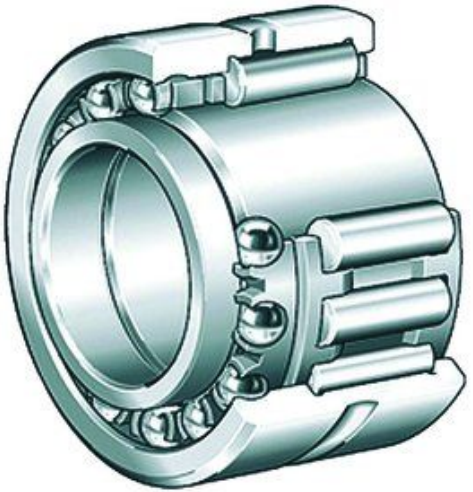
Couplings







Selection of Mechanical Components



How to select the bearing you want...???

$$F_{iA} \le (F_{iB} + F_{ae}) \qquad \begin{cases} F_{eA} = 0.4F_{rA} + K_A(F_{iB} + F_{ae}) \\ F_{eB} = F_{rB} \end{cases}$$

$$F_{iA} > (F_{iB} + F_{ae}) \qquad \begin{cases} F_{eB} = 0.4F_{rB} + K_B(F_{iA} - F_{ae}) \\ F_{eA} = F_{rA} \end{cases}$$

$$R_D = \exp\left[-\left(\frac{x_B - x_0}{\theta - x_0} \right)^b \right]$$

$$F_B x_B^{1/a} = F_D x_D^{1/a}$$

$$F_B = F_D \left(\frac{x_D}{x_B} \right)^{1/a}$$

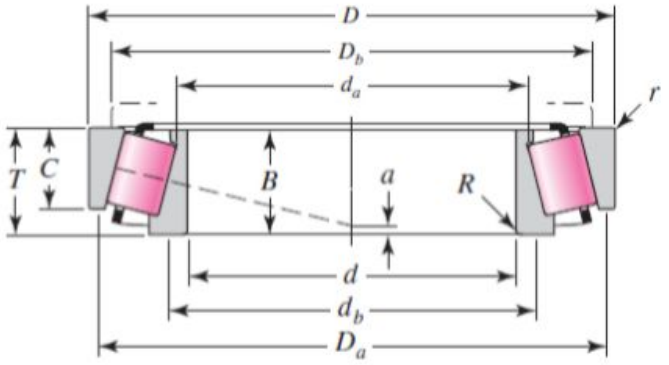
$$C_{10} = F_R = F_D \left(\frac{L_D}{L_R} \right)^{1/a} = F_D \left(\frac{\mathcal{L}_D n_D 60}{\mathcal{L}_R n_R 60} \right)^{1/a}$$

Dimensions and Load Ratings for Single-Row 02-Series Deep-Groove and Angular-Contact Ball Bearings

Bore, mm	OD, mm	Width, mm	Fillet Radius, mm	Shoulder Diameter, mm		Load Ratings, kN			
						Deep Groove		Angular Contact	
				d_S	d_H	C_{10}	C_0	C_{10}	C_0
10	30	9	0.6	12.5	27	5.07	2.24	4.94	2.12
12	32	10	0.6	14.5	28	6.89	3.10	7.02	3.05
15	35	11	0.6	17.5	31	7.80	3.55	8.06	3.65
17	40	12	0.6	19.5	34	9.56	4.50	9.95	4.75
20	47	14	1.0	25	41	12.7	6.20	13.3	6.55
25	52	15	1.0	30	47	14.0	6.95	14.8	7.65
30	62	16	1.0	35	55	19.5	10.0	20.3	11.0
35	72	17	1.0	41	65	25.5	13.7	27.0	15.0
40	80	18	1.0	46	72	30.7	16.6	31.9	18.6
45	85	19	1.0	52	77	33.2	18.6	35.8	21.2
50	90	20	1.0	56	82	35.1	19.6	37.7	22.8
55	100	21	1.5	63	90	43.6	25.0	46.2	28.5
60	110	22	1.5	70	99	47.5	28.0	55.9	35.5
65	120	23	1.5	74	109	55.9	34.0	63.7	41.5
70	125	24	1.5	79	114	61.8	37.5	68.9	45.5
75	130	25	1.5	86	119	66.3	40.5	71.5	49.0
80	140	26	2.0	93	127	70.2	45.0	80.6	55.0
85	150	28	2.0	99	136	83.2	53.0	90.4	63.0
90	160	30	2.0	104	146	95.6	62.0	106	73.5
95	170	32	2.0	110	156	108	69.5	121	85.0

									cone				cup			
bore	outside diameter	width	rating at 500 rpm for 3000 hours L_{10}		factor	eff. load center	part numbers		max shaft fillet radius	width	backing shoulder diameters		max housing fillet radius	width	backing shoulder diameters	
			one-row radial	thrust			cone	cup								
d	D	T	N lbf	N lbf	K	a②			R①	B	d_b	d_a	r①	C	D_b	D_a
25.000 0.9843	**52.000** 2.0472	**16.250** 0.6398	**8190** 1840	**5260** 1180	**1.56**	**–3.6** –0.14	◆30205	◆30205	**1.0** 0.04	**15.000** 0.5906	**30.5** 1.20	**29.0** 1.14	**1.0** 0.04	**13.000** 0.5118	**46.0** 1.81	**48.5** 1.91
25.000 0.9843	**52.000** 2.0472	**19.250** 0.7579	**9520** 2140	**9510** 2140	**1.00**	**–3.0** –0.12	◆32205-B	◆3								
25.000 0.9843	**52.000** 2.0472	**22.000** 0.8661	**13200** 2980	**7960** 1790	**1.66**	**–7.6** –0.30	◆33205	◆								
25.000 0.9843	**62.000** 2.4409	**18.250** 0.7185	**13000** 2930	**6680** 1500	**1.95**	**–5.1** –0.20	◆30305	◆								
25.000 0.9843	**62.000** 2.4409	**25.250** 0.9941	**17400** 3910	**8930** 2010	**1.95**	**–9.7** –0.38	◆32305	◆								
25.159 0.9905	**50.005** 1.9687	**13.495** 0.5313	**6990** 1570	**4810** 1080	**1.45**	**–2.8** –0.11	**07096**	(								
25.400 1.0000	**50.005** 1.9687	**13.495** 0.5313	**6990** 1570	**4810** 1080	**1.45**	**–2.8** –0.11	**07100**	(								
25.400 1.0000	**50.005** 1.9687	**13.495** 0.5313	**6990** 1570	**4810** 1080	**1.45**	**–2.8** –0.11	**07100-S**	(								
25.400 1.0000	**50.292** 1.9800	**14.224** 0.5600	**7210** 1620	**4620** 1040	**1.56**	**–3.3** –0.13	**L44642**	L								
25.400 1.0000	**50.292** 1.9800	**14.224** 0.5600	**7210** 1620	**4620** 1040	**1.56**	**–3.3** –0.13	**L44643**	**L44610**	**1.3** 0.05	**14.732** 0.5800	**31.5** 1.24	**29.5** 1.16	**1.3** 0.05	**10.668** 0.4200	**44.5** 1.75	**47.0** 1.85
25.400 1.0000	**51.994** 2.0470	**15.011** 0.5910	**6990** 1570	**4810** 1080	**1.45**	**–2.8** –0.11	**07100**	**07204**	**1.0** 0.04	**14.260** 0.5614	**30.5** 1.20	**29.5** 1.16	**1.3** 0.05	**12.700** 0.5000	**45.0** 1.77	**48.0** 1.89
25.400 1.0000	**56.896** 2.2400	**19.368** 0.7625	**10900** 2450	**5740** 1290	**1.90**	**–6.9** –0.27	**1780**	**1729**	**0.8** 0.03	**19.837** 0.7810	**30.5** 1.20	**30.0** 1.18	**1.3** 0.05	**15.875** 0.6250	**49.0** 1.93	**51.0** 2.01

SINGLE-ROW STRAIGHT BORE



Steps...

1. Identification of Problem Statement
2. Design and Calculations of the parts to be made
3. Manufacturing of Parts
4. Selection of Mechanical Components
5. Final Assembly
6. Testing
7. Repeat

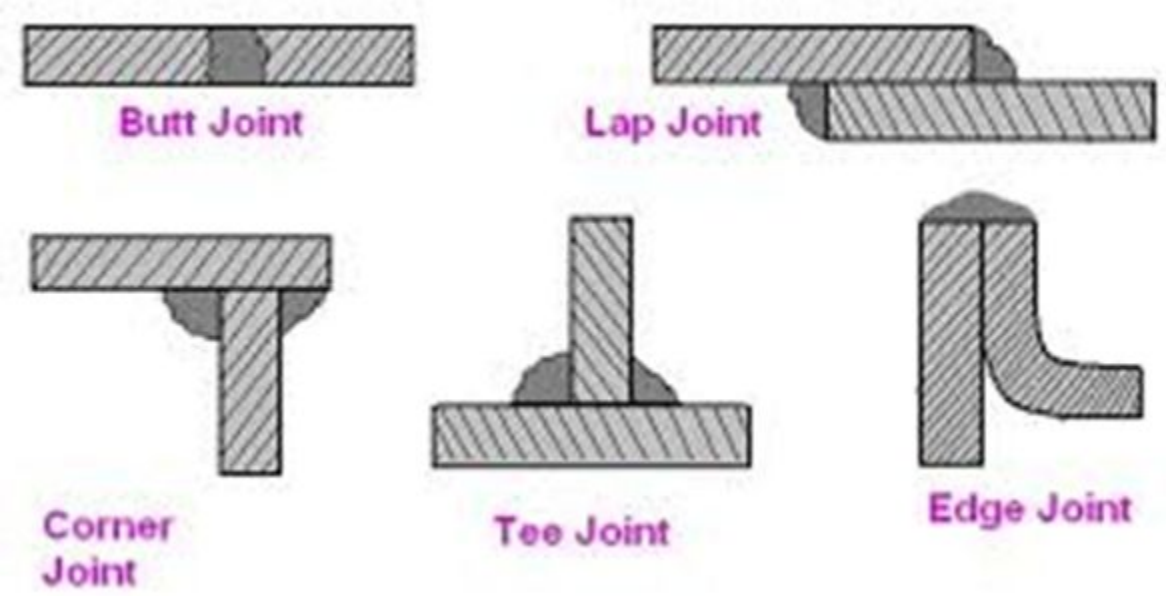
Final Assembly

Final Assembly

- The process of assembly can be basically defined as **joining together all the parts and components.**

- This process of joining can take place in 2 forms -
  - Permanent Joints
  - Non permanent Joints

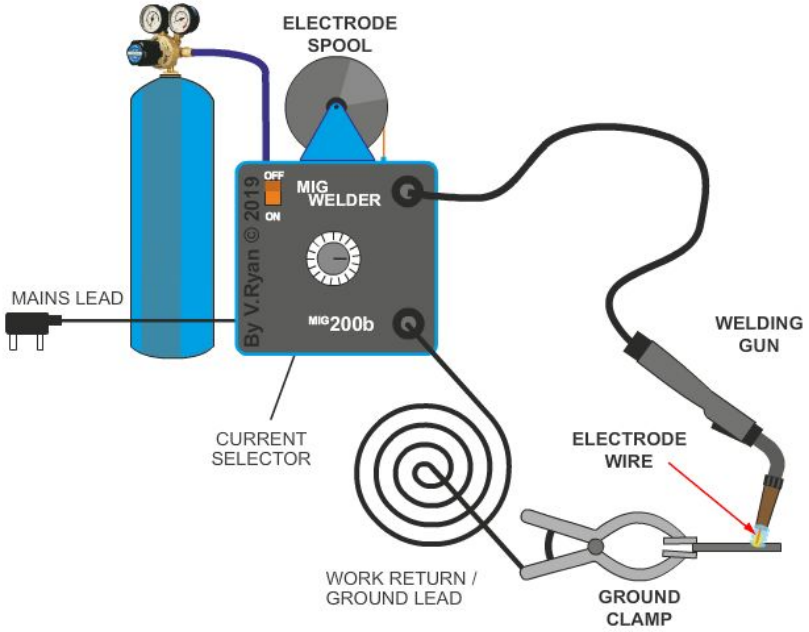
Permanent Joint - Welding



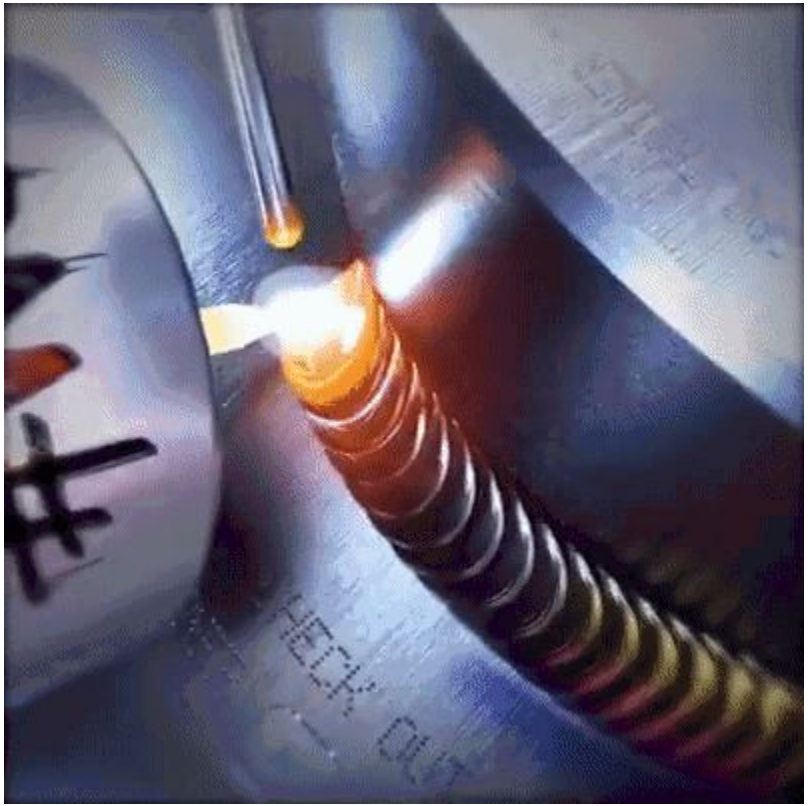
Types of Welding

- Gas welding
- Arc Welding
- MIG
- TIG
- Spot Welding

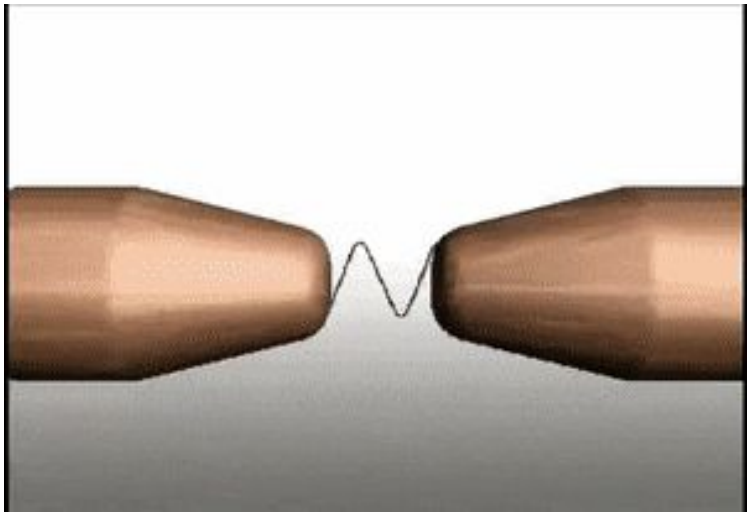
MIG Welding


ELECTRODE
SPOOL
OFF
ON
MIG
WELDER
By V.Ryan © 2019
MAINS LEAD
MIG 200b
WELDING
GUN
CURRENT
SELECTOR
ELECTRODE
WIRE
WORK RETURN /
GROUND LEAD
GROUND
CLAMP

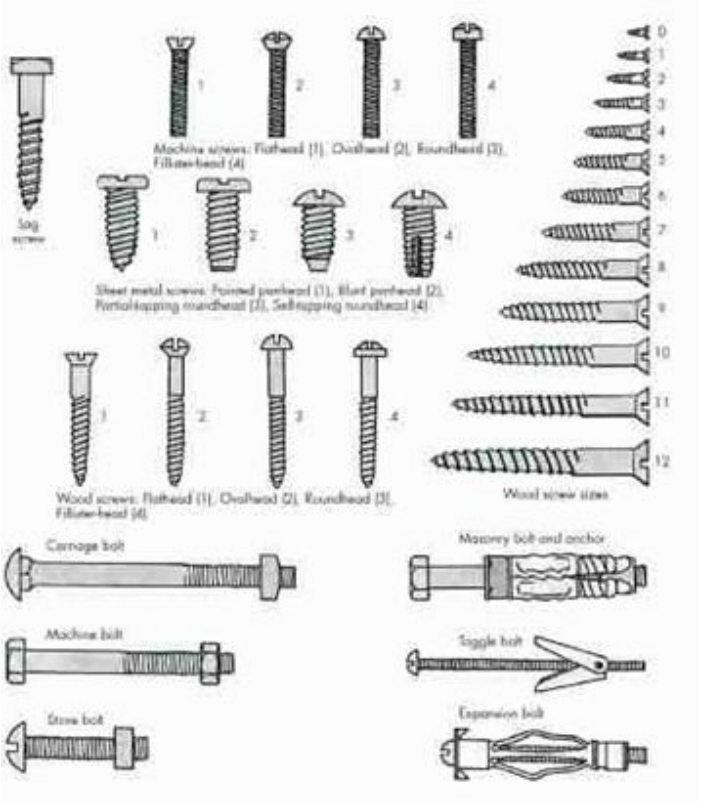
TIG Welding

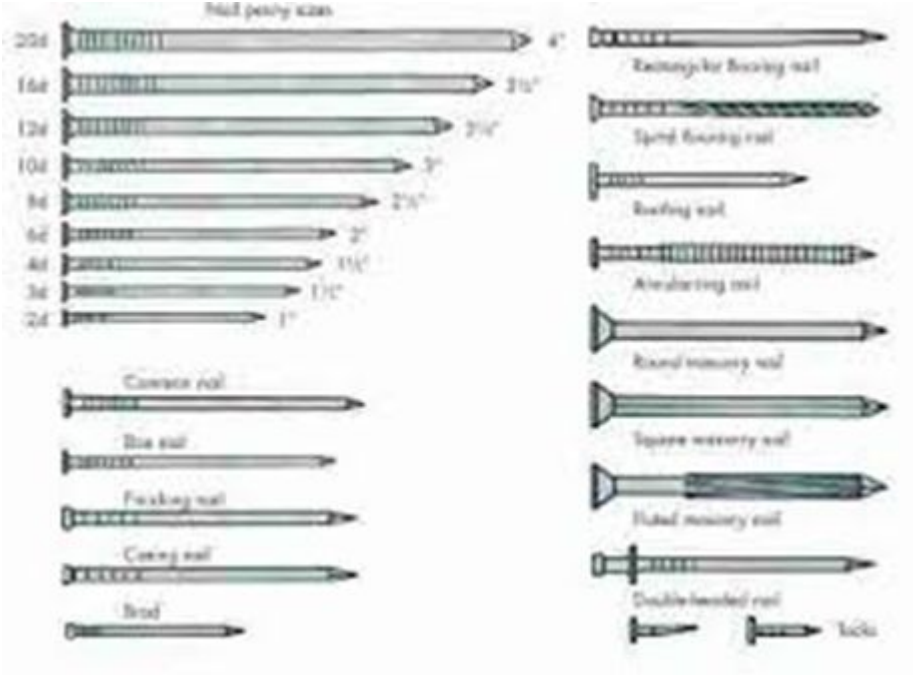


Spot Welding

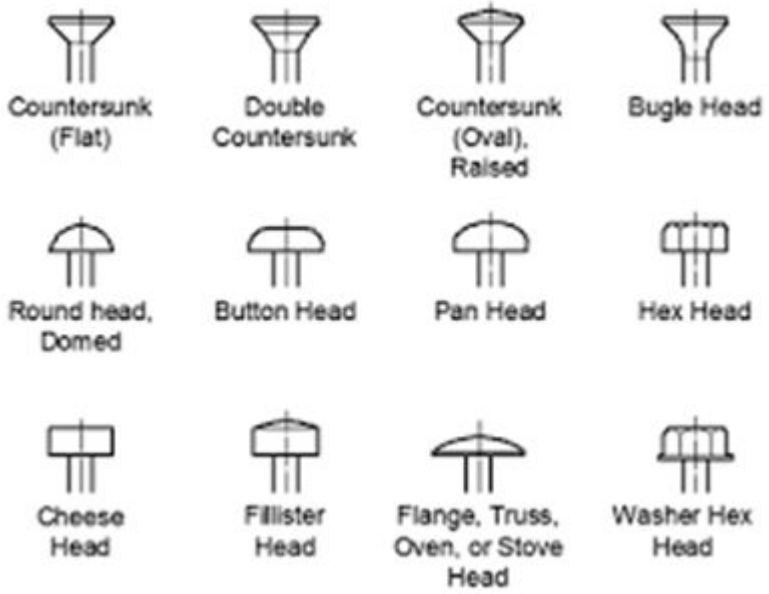


Non Permanent Joints

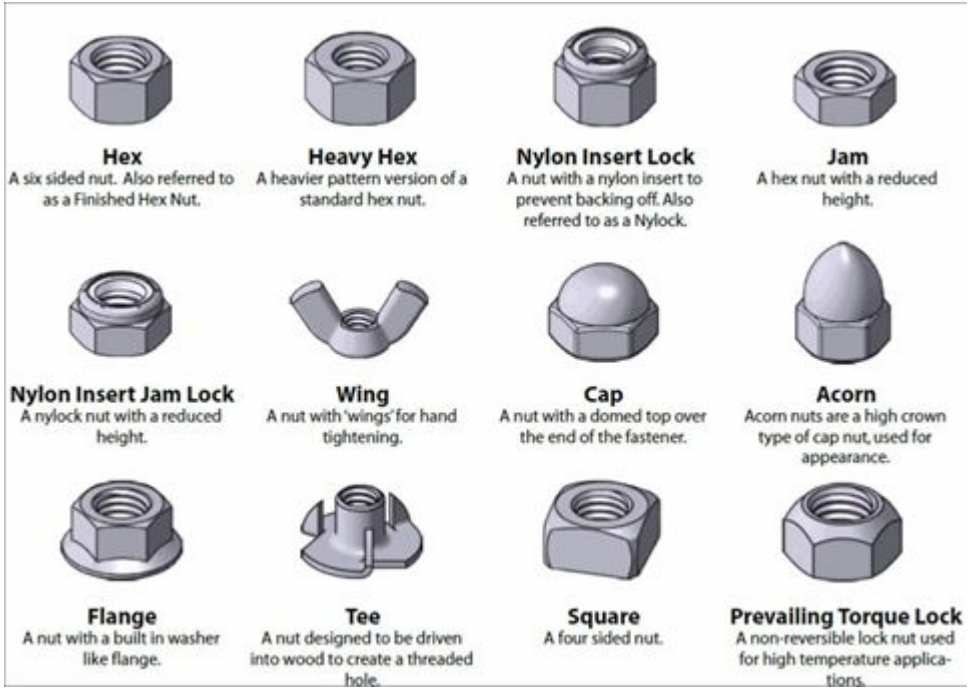


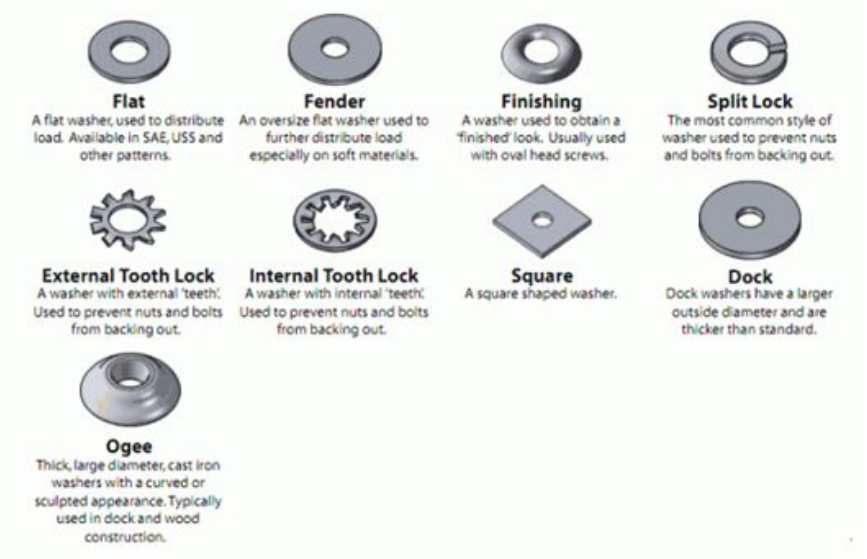


Non Permanent Joints



Non Permanent Joints



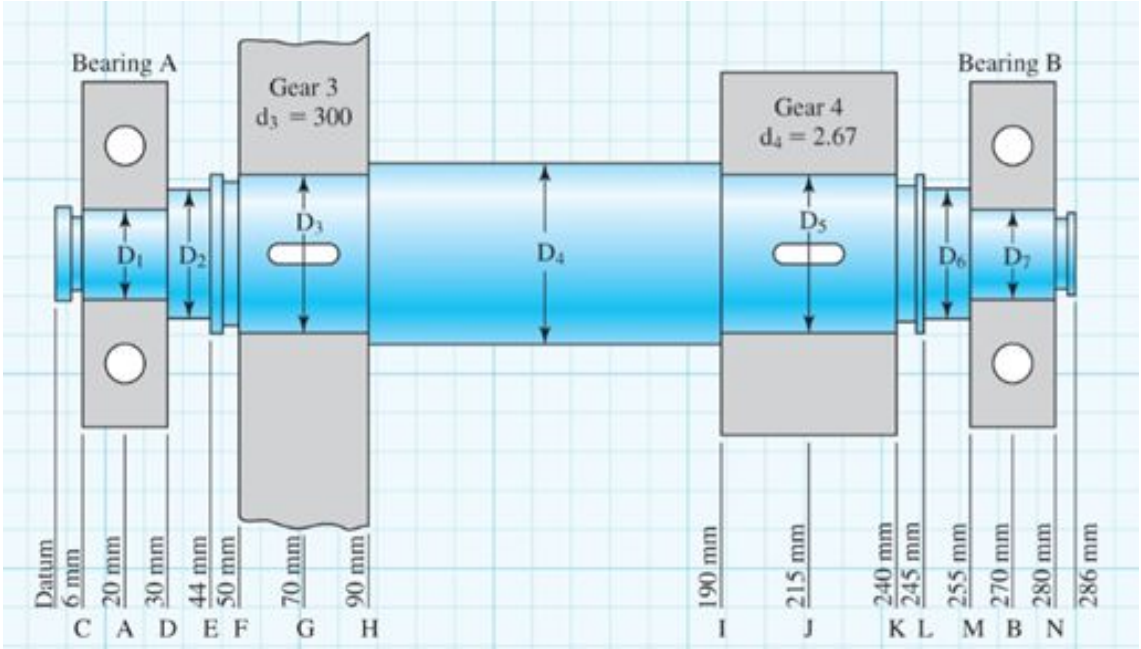


Steps...

1. Identification of Problem Statement
2. Design and Calculations of the parts to be made
3. Manufacturing of Parts
4. Selection of Mechanical Components
5. Final Assembly
6. Testing
7. Repeat

Testing

Balancing of Shafts



Balancing of Shafts

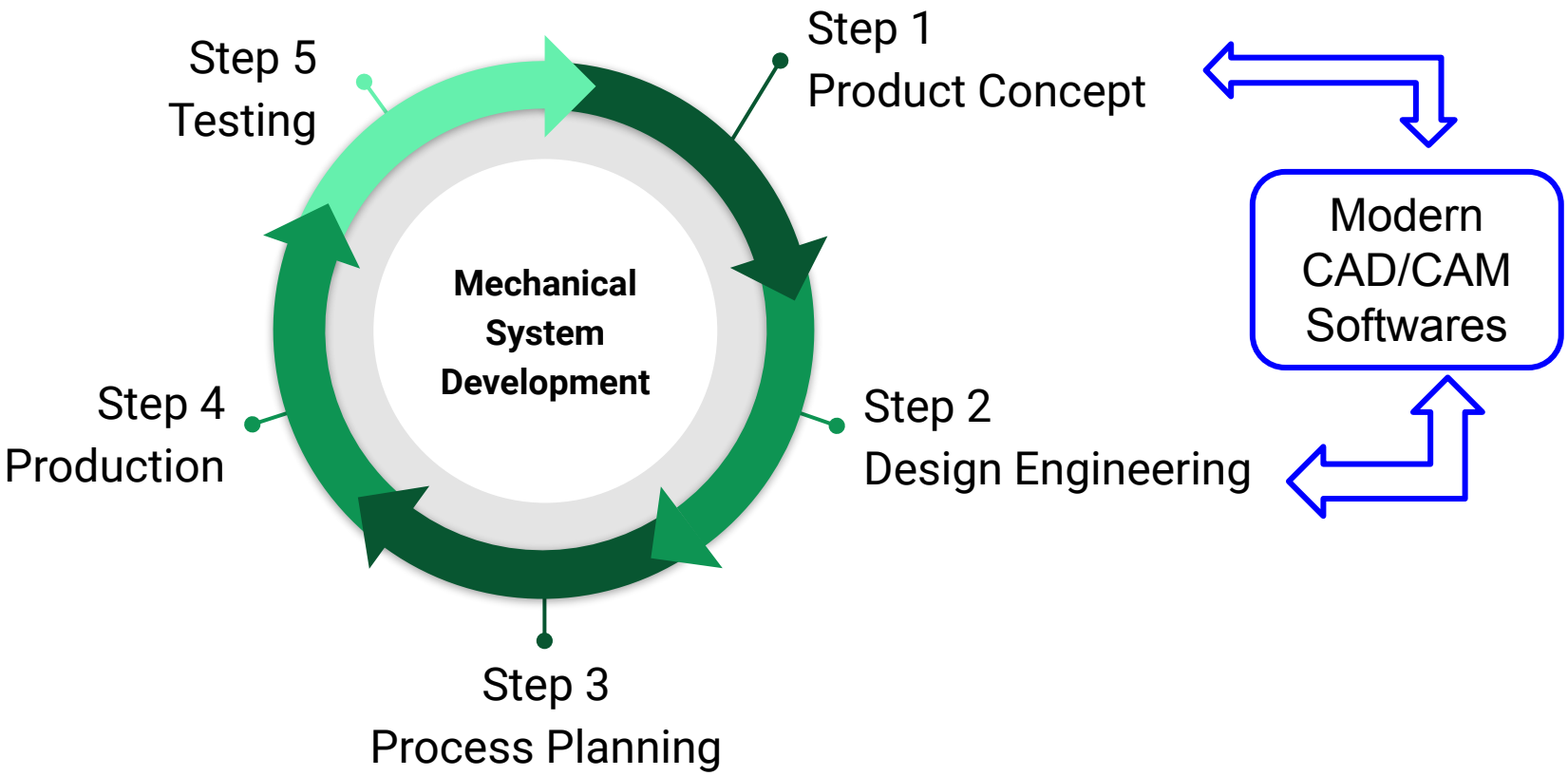
- Static Balancing-

Adjusting the components on the shaft such that shaft is balanced when stationary.

- Dynamic Balancing-

Placing components such that the forces on the shaft are balanced when the shaft is in motion (rotation).

RE-ITERATE


Step 1
Product Concept
Step 2
Design Engineering
Step 3
Process Planning
Step 4
Production
Step 5
Testing
Mechanical System Development
Modern CAD/CAM Softwares

Thank You

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