

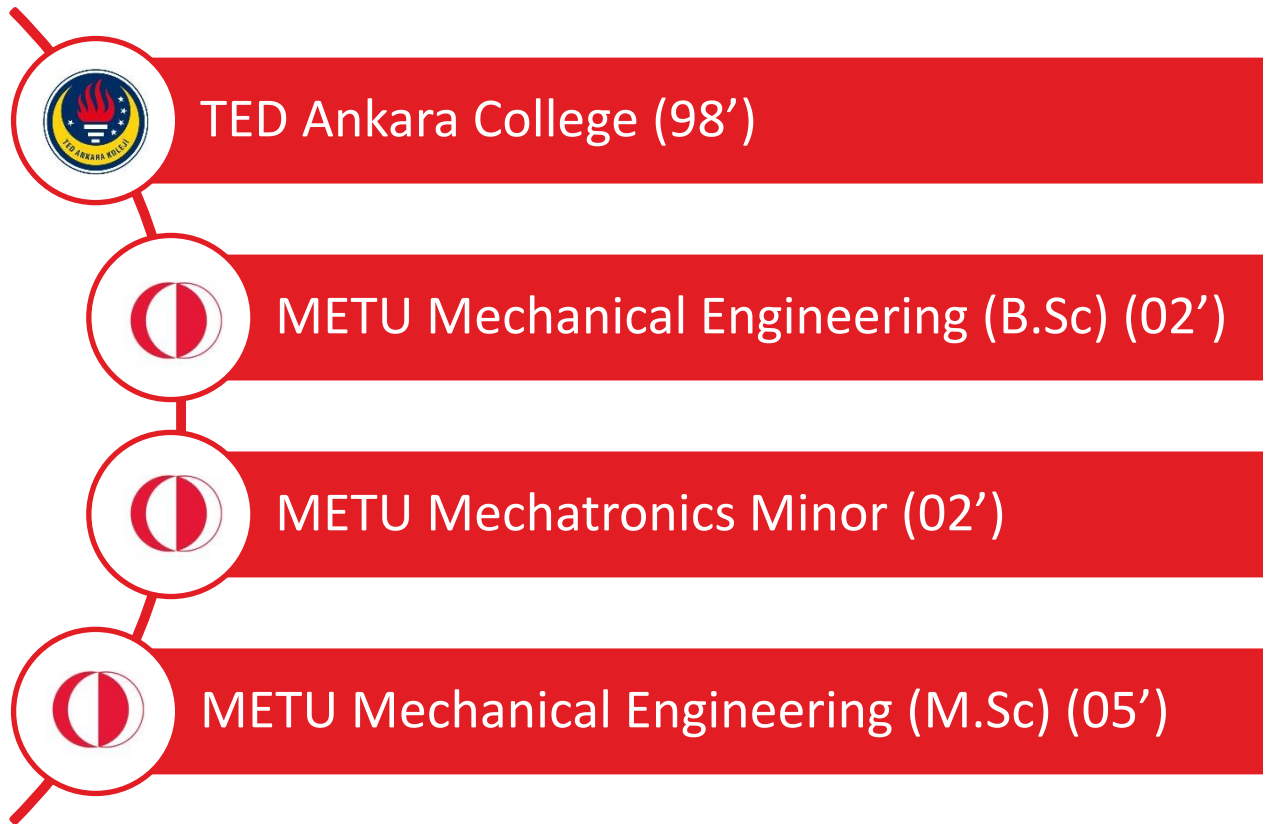


# MACHINE ELEMENTS

a quick look

**NEJAT ULUSAL**

Mechanical Engineer M.Sc





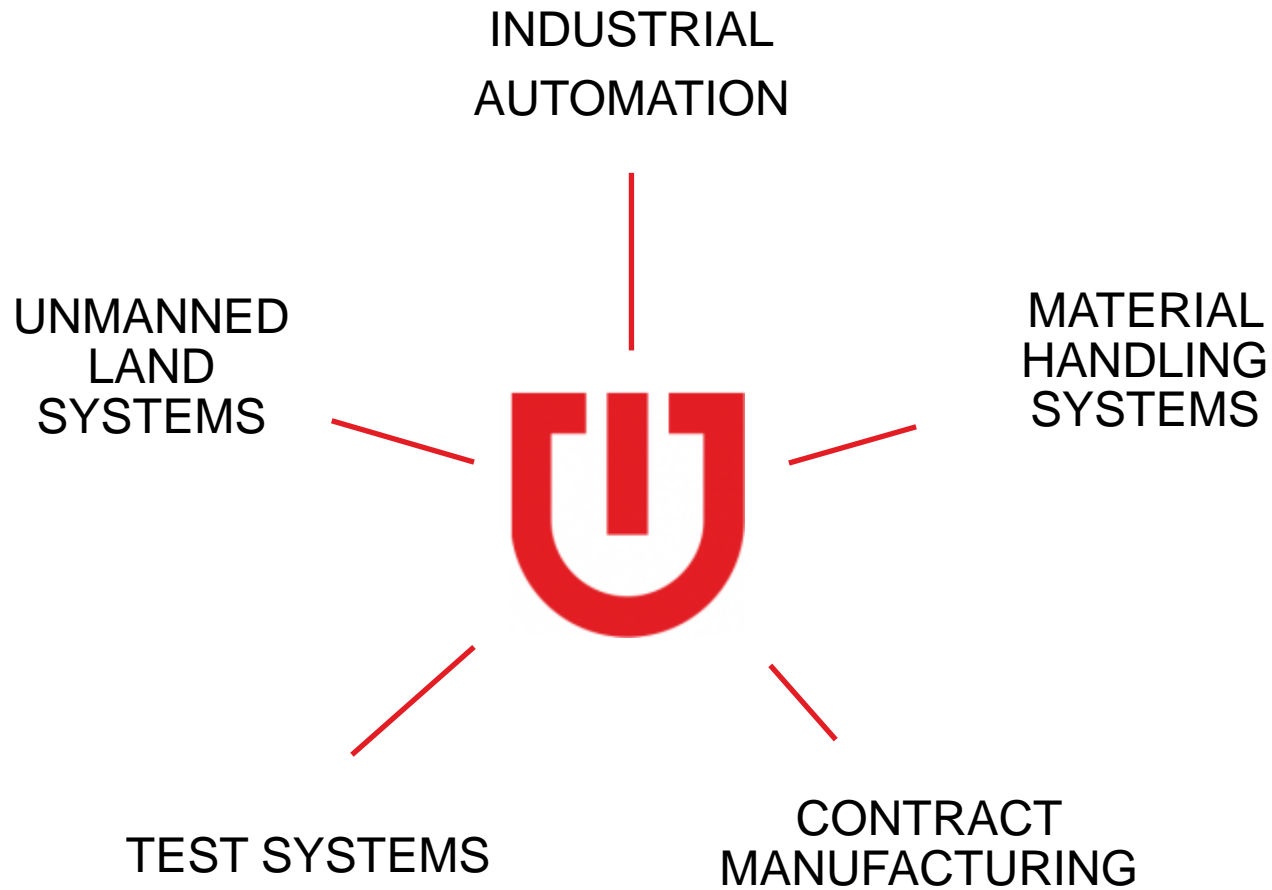
### TÜBİTAK-SAGE (02'-06')

- Researcher – Mechanical Production Division
- Team Leader – Ammunition Assembly Machines
- Facility Responsible – Mechanical Production Facility



### ULUSAL MAKİNA (06'-Present)

- Unmanned Land Systems
- Industrial Automation Systems,
- Design, Manufacturing and Control of Special Purpose Systems





500kg Autonomous  
Ground Vehicle



85kg EOD Robot



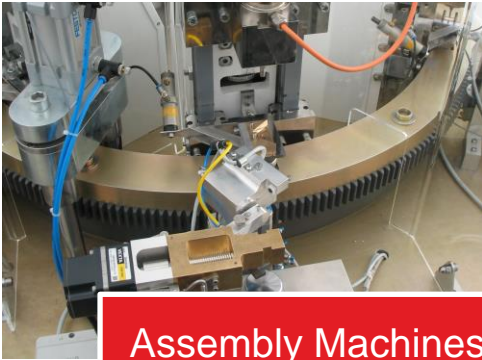
165kg EOD Robot



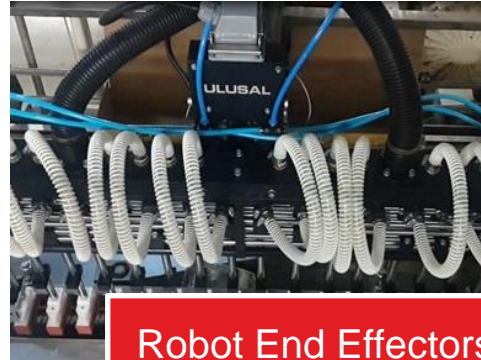
GPR Robot



Unmanned Target and  
Surveillance Boats



Assembly Machines



Robot End Effectors



Test Systems



Medical Devices



Special Purpose  
Positioners



Elevator Conveyors



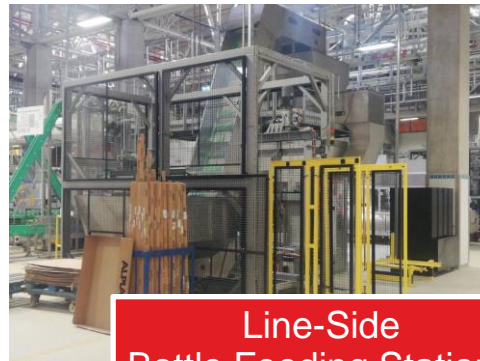
Conveyor Systems



Top Modules for AGV's



Pallet Stackers



Line-Side  
Bottle Feeding Stations

WHAT WE DO?



## UNDERSTANDING THE REQUIREMENTS

- Every item on the requirement list has to have at least one significant design element to fulfill that requirement

## DESIGN IN THE COMPUTER ENVIRONMENT

- Make a conceptual design by hand sketches
- Select your components from commercially available products
- Start detailing your conceptual mechanical design in a CAD environment  
*Autodesk Inventor, Siemens NX, Autodesk Fusion 360, Solidworks*
- Place open source CAD drawing of the components in your CAD model  
*Grabcad, Traceparts, b2b.partcommunity*
- Start designing your custom parts between components
- Select raw material and manufacturing process for the parts you design
- Iterate your design according to the manufacturing method you chose
- Finalize your design in CAD by placing every single component in CAD (fasteners etc.)



# Aluminium Alloys

## 7000 Series

- 7075 Widely used for high strength  
Welding is possible but not preferred  
Helicoils are not needed

## 6000 Series

- 6061 Very good for machining
- 6082 Common alternative of 6061  
Suitable for marine applications

## 5000 Series

- 5754 Sheets can be easily found and preferred for laser cutting
- 5083 Widely used for extruded bars, pipes etc.

Note: Helicoil inserts are needed for threads in Aluminium.  
(7075 can be considered as an exception.)

# Stainless Steels

## AISI 303

- Cheapest
- Machining is easier
- It will corrode

## AISI 304

- Hard to machine
- Resistant to corrosion in terrestrial applications

## AISI 316

- Hard to machine
- Suitable for Marine applications

# Steel Alloys

## AISI 1040

- Widely Used
- Suitable for Machining

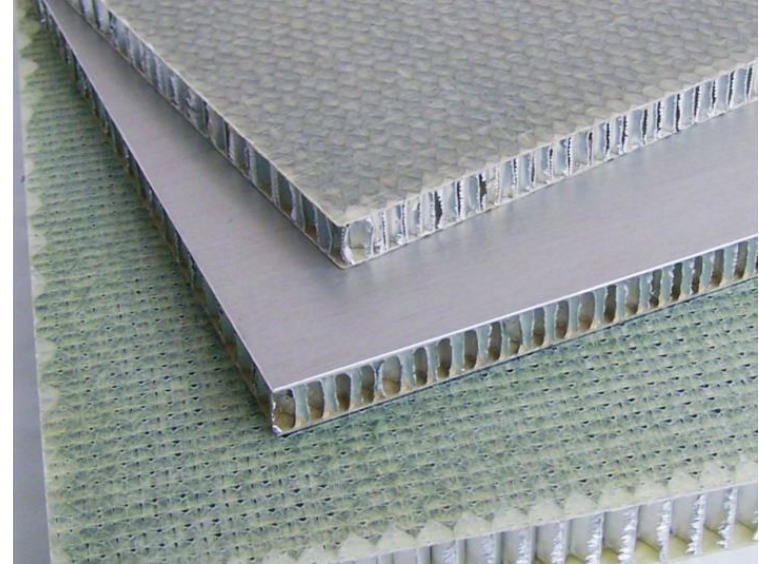
## AISI 4140

- Can be heat treated
- Widely used for high strength needs

## AISI 8620

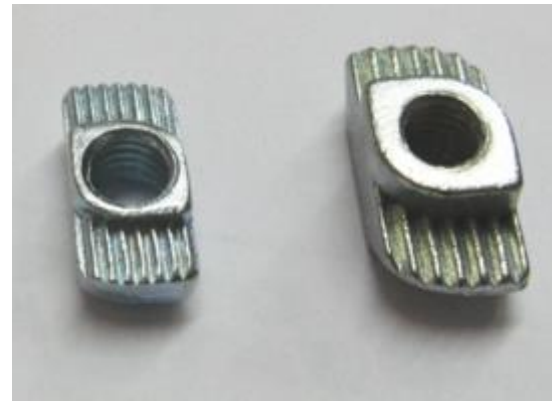
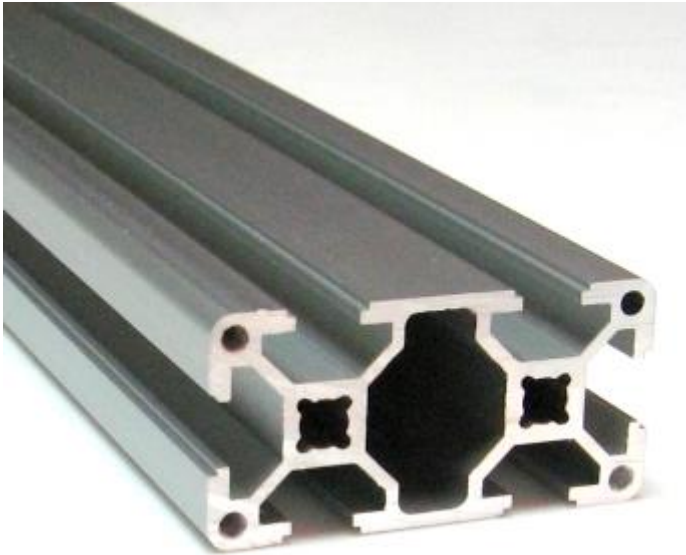
- Can be heat treated by carburisation
- Used for manufacturing of gear trains

# Composite Materials



Pipes of different diameters and honeycomb panels can be found on the market.

# Aluminium Profiles and Accessories



Practical for light structures

Wide range of accessories for different applications

# Bolts

DIN931-DIN933 Hex Head Fasteners



DIN912-DIN6912 Socket Head Fasteners

DIN7991 Flat Head Countersunk Socket



*Preferred Sizes of Metric Fasteners*

*M2 M2.5 M3 M4 M5 M6 M8 M10 M12 M14 M16 M20 M24 M30 M36 M42*

# Machine Screws





# Nuts

DIN934-Hexagon Nut



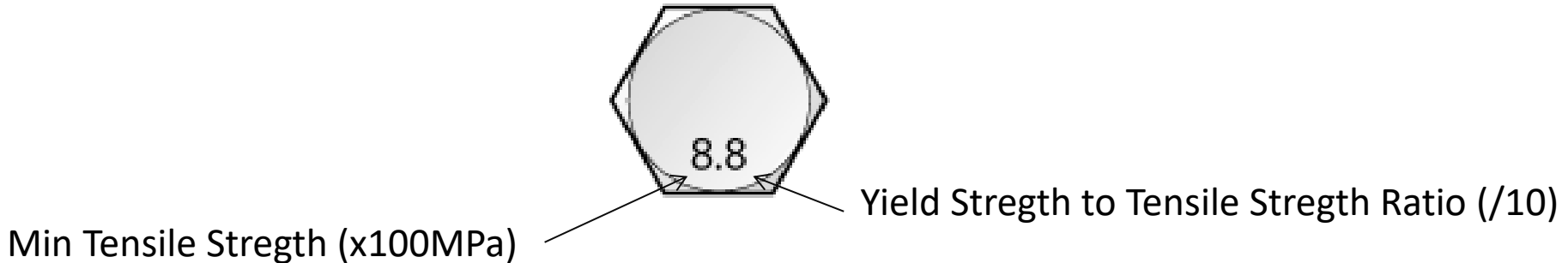
DIN985-Nylon Insert Nut

# Set Screws

DIN913



# Bolt Grades



For 8.8 Grade Bolt

Min Tensile Strength=800MPa

Min Yield Strength =800 x 0,8 =640MPa



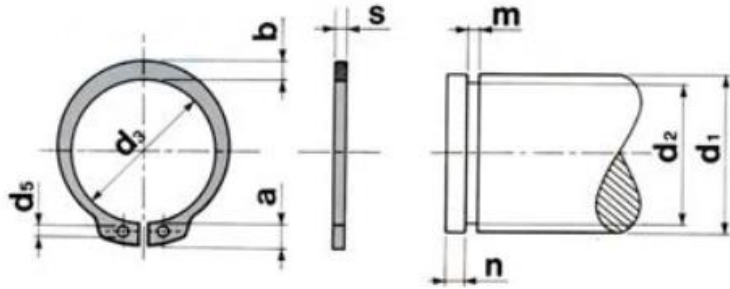
For 12.9 Grade Bolt

Min Tensile Strength=1200MPa

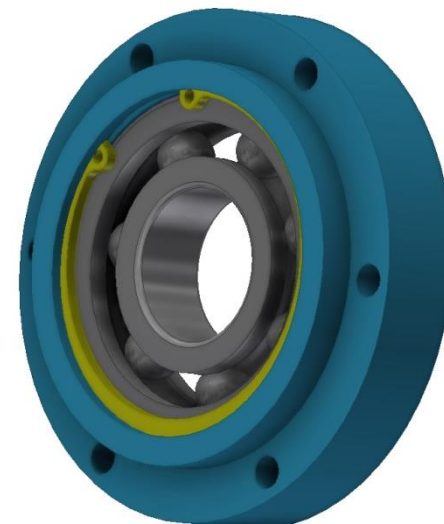
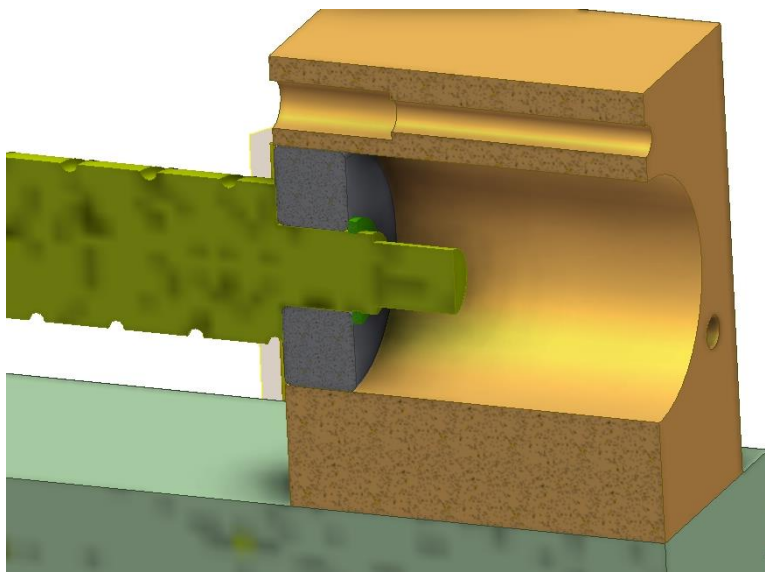
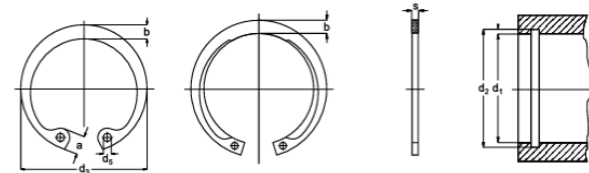
Min Yield Strength =1200 x 0,9 =1080MPa

*Common Bolt Grades: 4.6 5.8 8.8 10.9 12.9*

## DIN471 – EXTERNAL CIRCLIPS



## DIN472 – INTERNAL CIRCLIPS



Standard groove dimensions can be machined easily.

# Rail Systems



# Linear Bushing Systems



# Plain Bushes



# Housing Units



*Common codes : UCF,UCFL,UCFC,UCP,UCPA*

GUIDING ROTATIONAL MOTION

# Bearings

Deep Groove Ball Bearings  
(60xx -62xx-63xx Series)

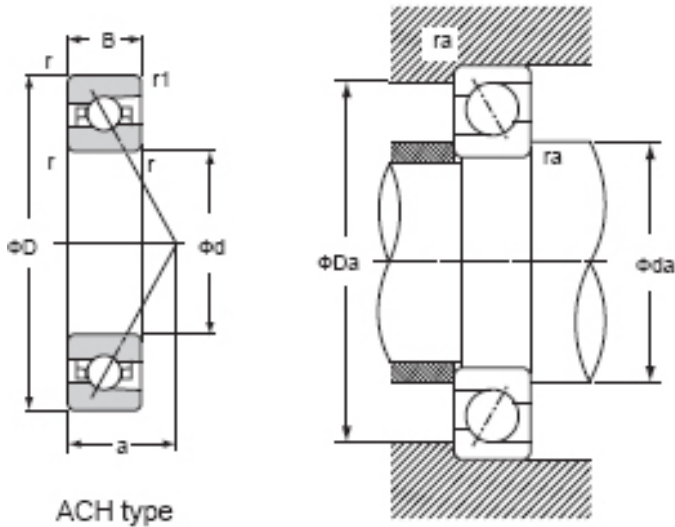


Deep Groove Ball Bearings  
Double Row  
(42xx-43xx Series)

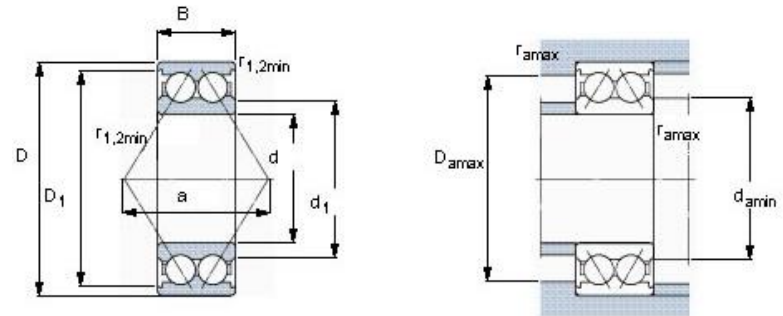


# Bearings

## Angular Contact Ball Bearings (72xx-73xx Series)



## Double Row Angular Contact Ball Bearings (32xx-33xx Series)

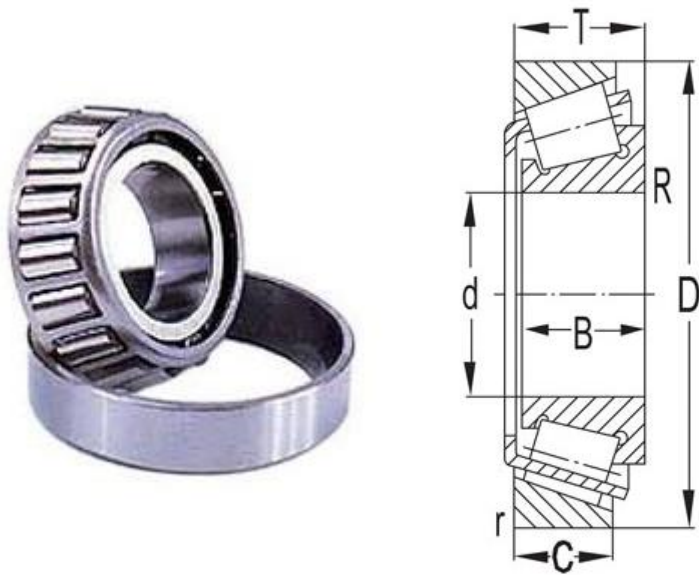


For supporting radial and axial loads on assemblies like Power Screws, Ball Screws etc.

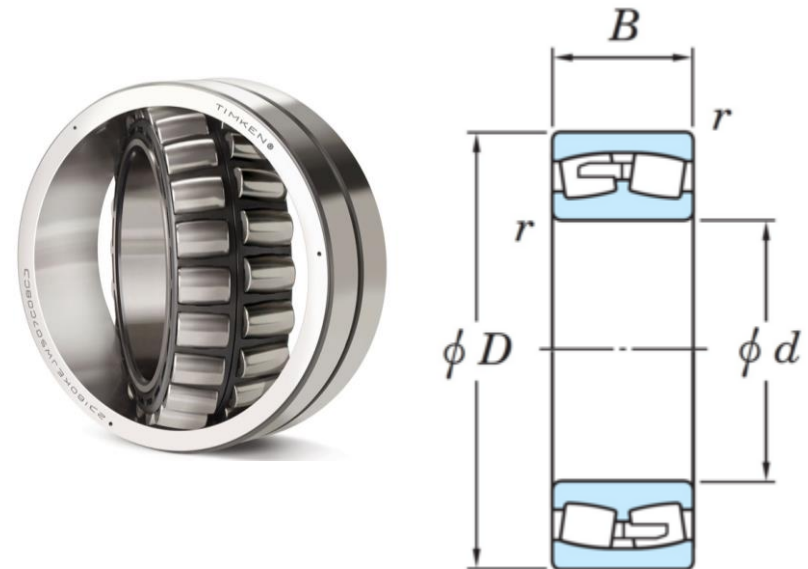


# Bearings

Tapered Roller Bearing  
(30xxx-31xxx-32xxx-33xxx Series)



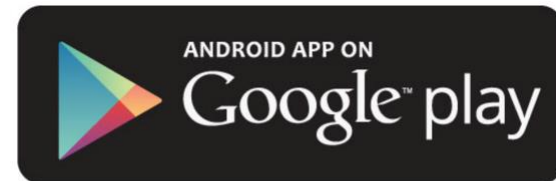
Spherical Roller Bearing  
(21xxx-22xxx Series)










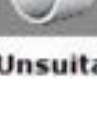
# Bearings

For sizing and selection of the bearings:

SKF Bearing Calculator Application



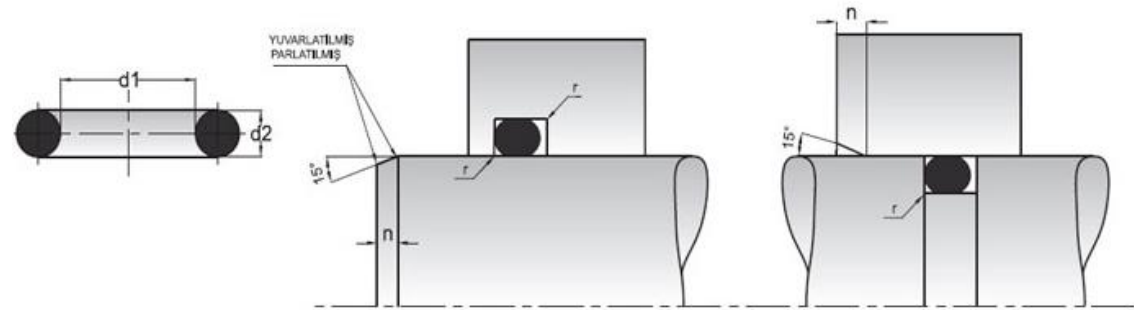
# Bearings

Bearing type		Radial load	Axial load	Compensation of misalignment	Accuracy	High speed	Low noise	Low friction
Deep groove ball bearing		Good	Normal	Normal	Normal	Very good	Very good	Very good
Single row angular contact ball bearing		Good	Good (in one direction)	Unsuitable	Normal	Very good	Good	Good
Spindle bearing		Good	Good (in one direction)	Unsuitable	Very good	Very good	Very good	Very good
Cylindrical roller bearing with cage		Very good	Unsuitable ... good *)	Sufficient	Good	Good	Sufficient	Good
Tapered roller bearing		Very good	Very good (in one direction)	Sufficient	Sufficient	Normal	Good	Good
Spherical roller bearing		Very good	Good	Very good	Unsuitable	Normal	Sufficient	Good
Axial spherical roller bearing		Sufficient	Very good (in one direction)	Very good	Unsuitable	Good	Sufficient	Unsuitable
Plain bearing		Very good	Sufficient	Normal	Sufficient	Good	Normal	Sufficient

\*) N and NU design: Unsuitable, NUP design: Good, NJ design: Good (in one direction)

GUIDING ROTATIONAL MOTION

# O-Rings



For O-Ring and corresponding groove dimensions

[www.kastas.com.tr](http://www.kastas.com.tr)

# Seals (Keçeler)

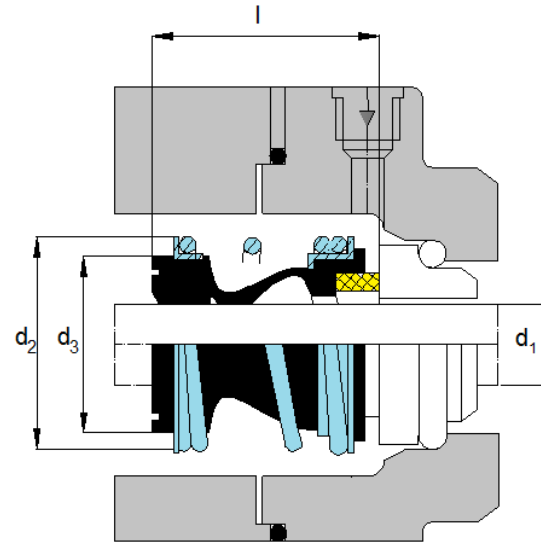
## Sealing Elements for Linear and Rotational Motion



For types, sizes and corresponding groove dimensions  
[www.kastas.com.tr](http://www.kastas.com.tr) / [www.suptex.com.tr](http://www.suptex.com.tr)

# Compression Seal Fitting (Salmastra)

## Sealing of Rotational Elements





# MACHINE ELEMENTS

a quick look

NEJAT ULUSAL  
Mechanical Engineer M.Sc

22 February 2022





**Spur Gears**  
Transmissions



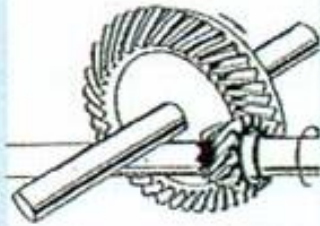
**Straight Bevel Gears**  
Industrial Equipment  
Some Differentials



**Spiral Bevel Gears**  
Industrial Equipment  
Some Differentials



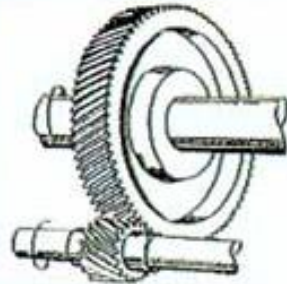
**Worm Gear Set**  
Gear Reduction Boxes



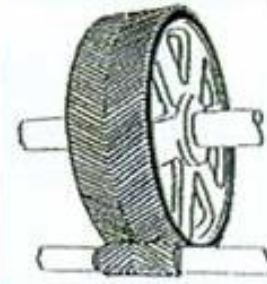
**Hypoid Gears**  
Differentials



**Planetary Gear Set**  
Transmissions



**Helical Gears**  
Transmissions



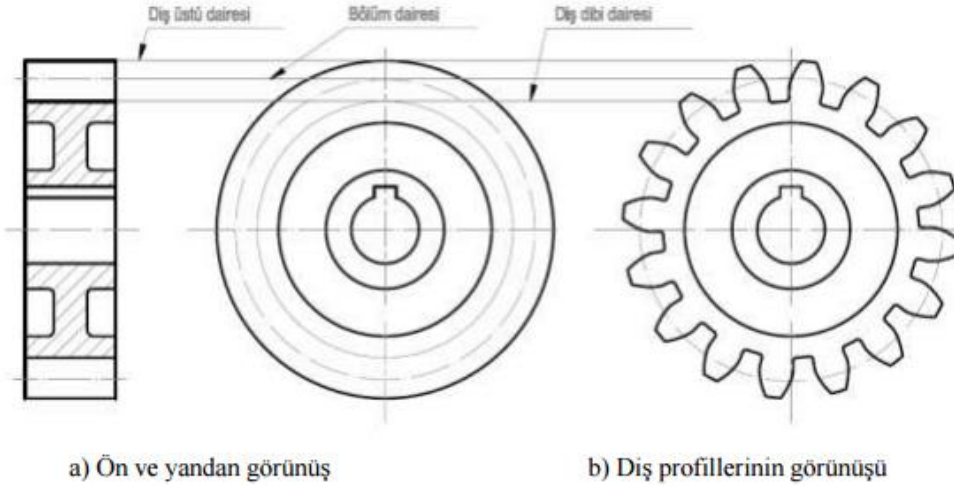
**Herringbone Gears**  
Transmissions

Düz Dişli Çark		
Modül	m	.....
Diş sayısı	z	.....
Diş profili		<b>TS3601</b>
Diş derinliği	h	.....
Eş dişli diş sayısı	$Z_2$	.....
Eksenler arası	E	.....

Tablo 2.2: Düz dişli çark açıklama tablosu

Ölçü	Ebö	Ekö
10D10	10,098	10,040
$\varnothing 30H7$	30,021	30

Tablo 2.3: Düz dişli çark tolerans anteti



For manufacturing of other gear types there is a very good handbook:

Ministry of National Education  
 Milli Eğitim Bakanlığı  
 MEGEP – Dişli Çark Açmak



Standard Industrial  
Worm Gear Box



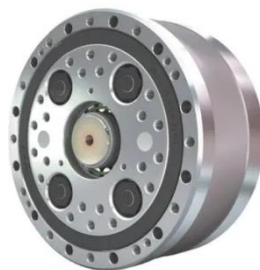
Small Sized  
Spur Gear Box



Bevel Gearbox



Harmonic  
Gearbox



Cycloid Gearbox



Planetary Gearbox

# Rack & Pinion

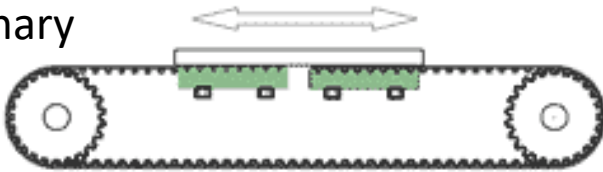


Suitable for  
-long travel distances  
-harsh industrial environments

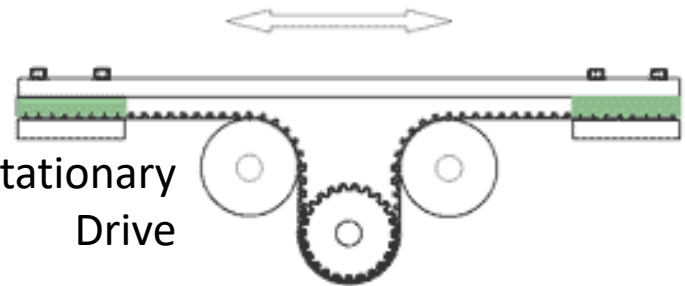
ELEMENTS TO CONVERT  
ROTARY MOTION TO LINEAR MOTION

# Toothed Belt or Chain Drive Systems

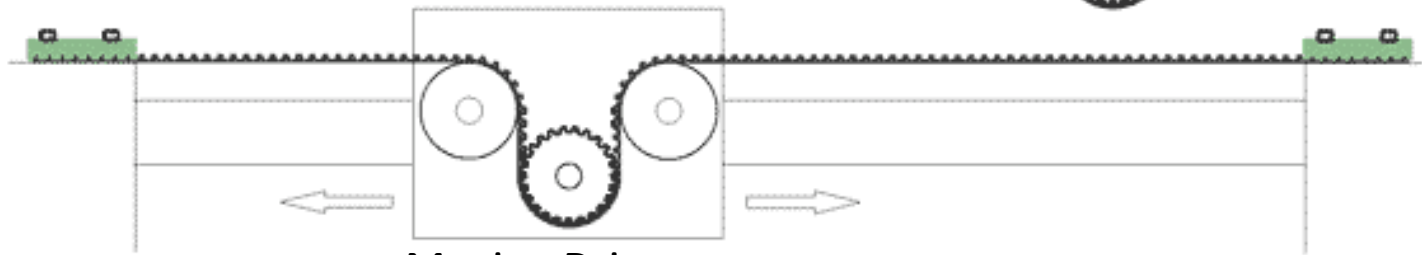
Stationary Drive



Stationary Drive



Moving Drive

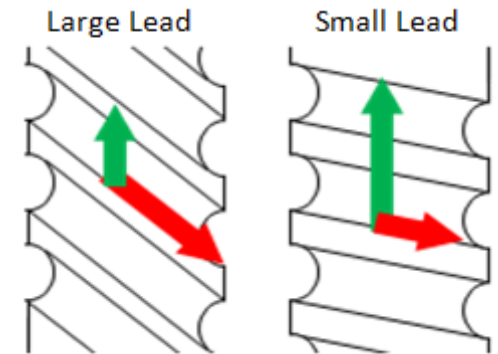
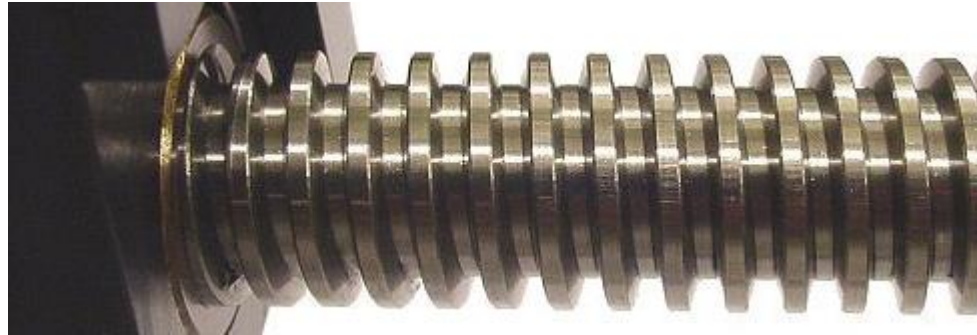


Suitable for

- Long travel distances
- Silent
- Highly Dynamic



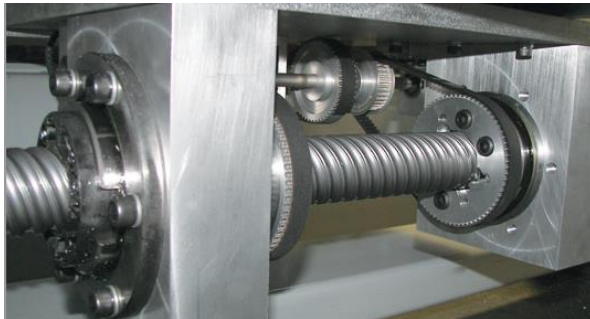
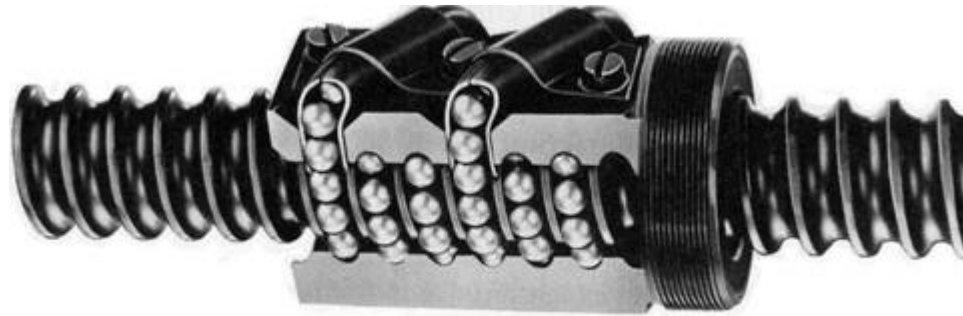
# Power Screws



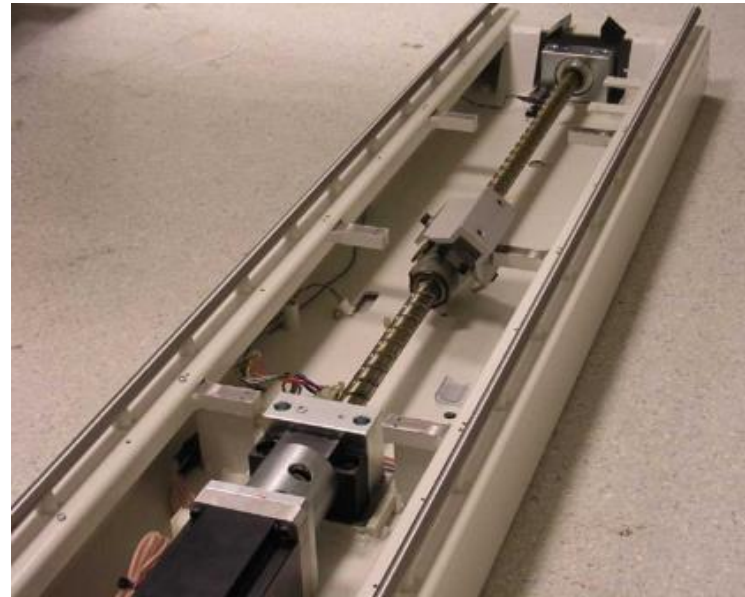
Suitable for  
-applications where self-locking is required

ELEMENTS TO CONVERT  
ROTARY MOTION TO LINEAR MOTION

# Ball Screws



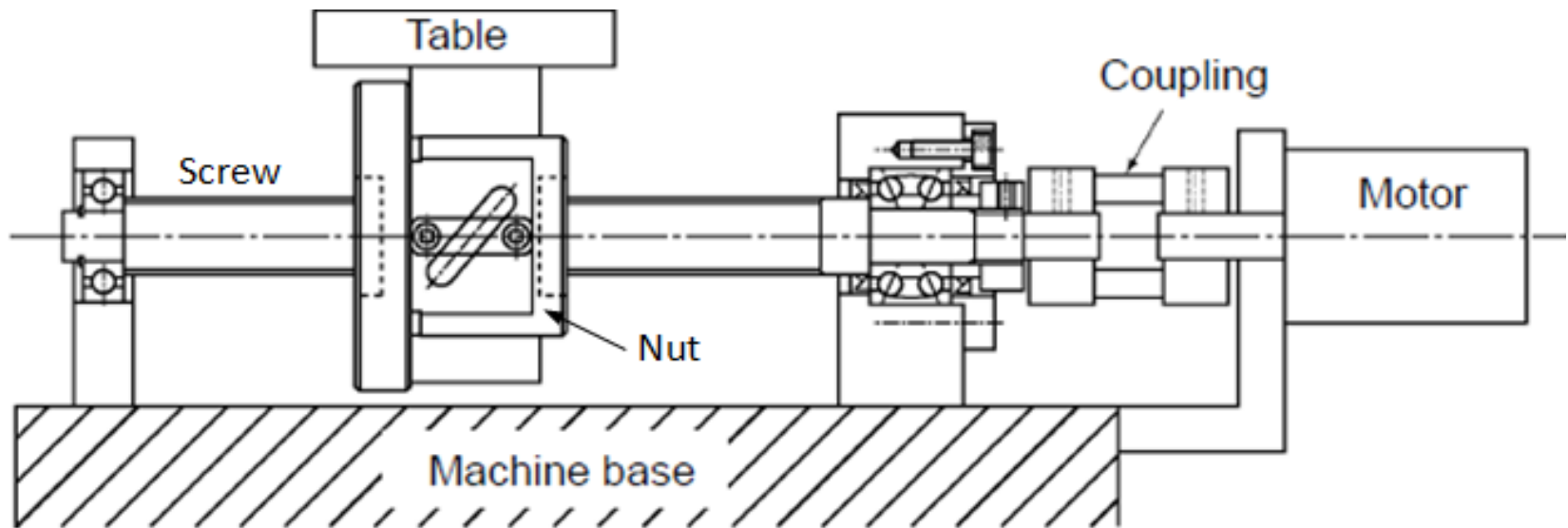
Advantage  
-High Efficiency



ELEMENTS TO CONVERT  
ROTARY MOTION TO LINEAR MOTION



# Typical Ball Screw Assembly



ELEMENTS TO CONVERT  
ROTARY MOTION TO LINEAR MOTION

# V-Belts



High Speed-Low Torque Applications  
Slipping is not eliminated  
No synchronisation  
Tensioning is needed

# Timing Belts



High Torque Applications  
Slipping is eliminated  
Synchronised  
Tensioning is needed

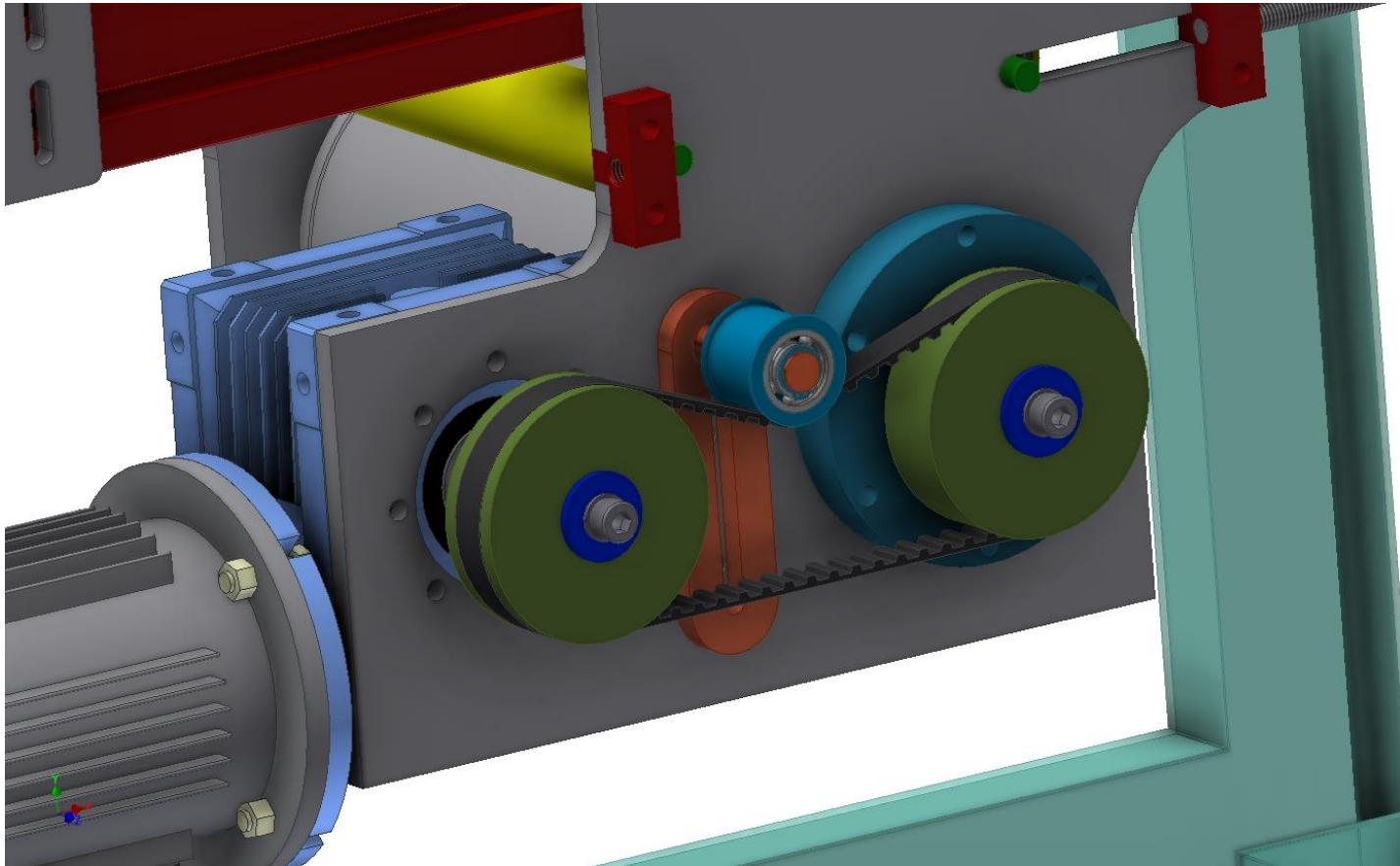
*Common Types*

*Imperial Units : XL-L-XH*

*SI Units: 3M-5M-8M & T5-T10*

PLANAR TORQUE TRANSMISSION  
BETWEEN PARALEL SHAFTS

# Timing Belt Application

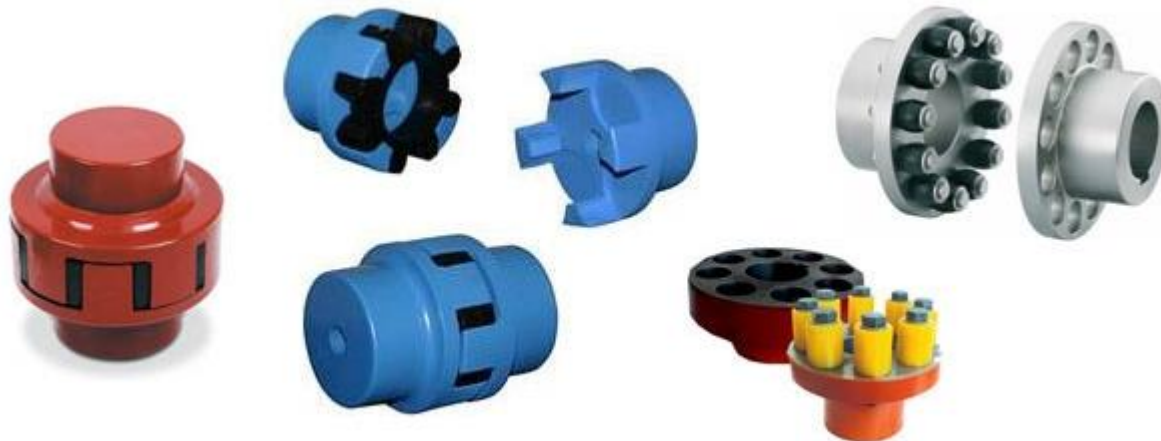


PLANAR TORQUE TRANSMISSION  
BETWEEN PARALEL SHAFTS

# Chain Drives

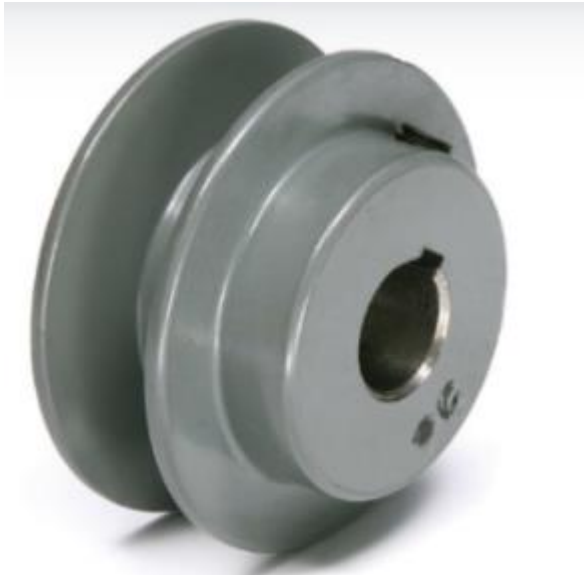


- High Torque Applications
- Slipping is eliminated
- Synchronised
- Tensioning is needed
- Needs maintenance
- Suitable for narrow spaces



## COUPLINGS



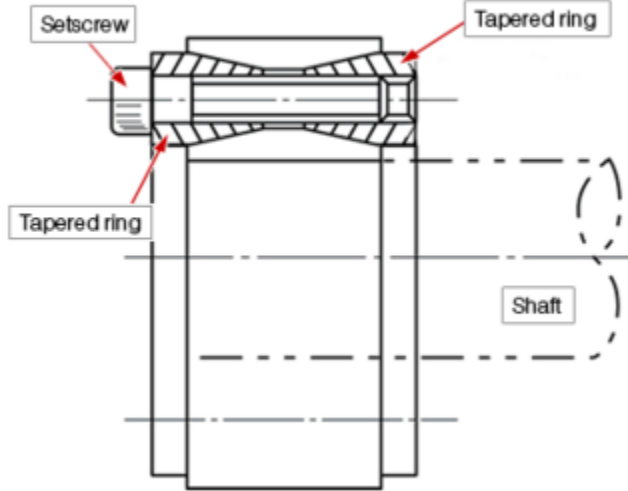


Refer to DIN6885  
For keyway dimensions



No precaution for backlash

[Fig. 2] Double conical Mecha-lock



- No special machining for transmission of the torque
- No backlash
- More radial space is required

## DOUBLE CONICAL MECHANICAL LOCK



## WELDING

- TIG
- MIG

## MACHINING

- Turning
- Milling
- Broaching
- Grinding

## ELECTRICAL DISCHARGE MACHINING (EDM)

- Die Sink EDM
- Wire Cut EDM

## SHEET MATERIAL

- Cutting (Laser – Plasma)
- Bending

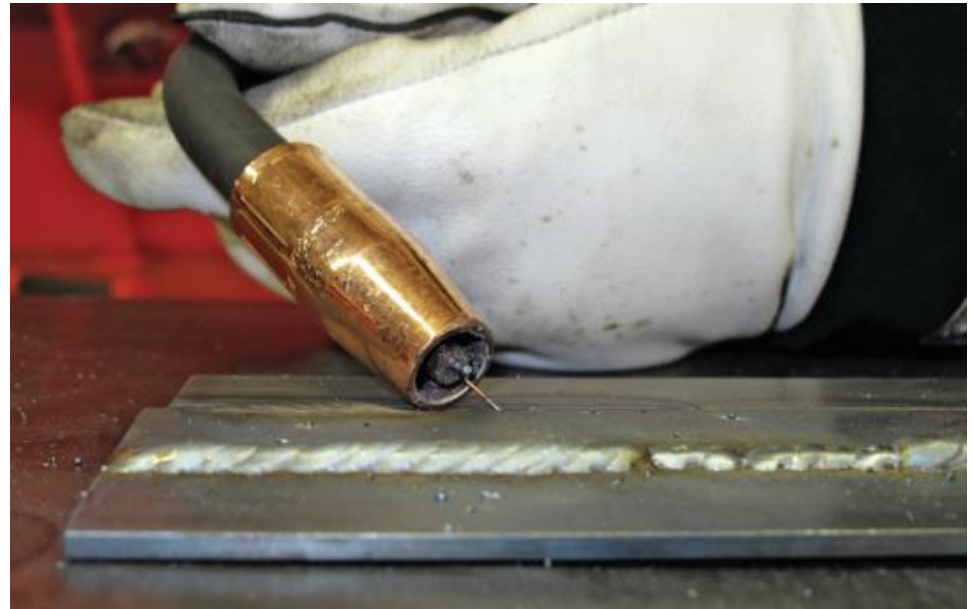
# TIG-Tungsten Inert Gas Welding

- Suitable for thinner cross-sections
- Aluminium, Bronze can also be welded



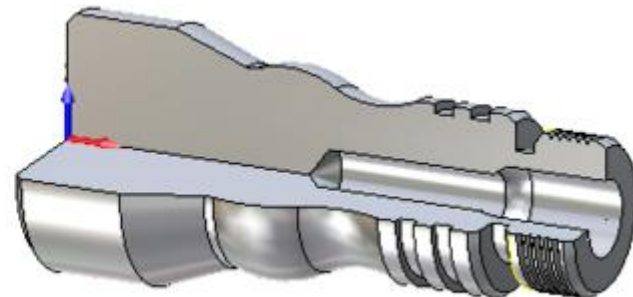
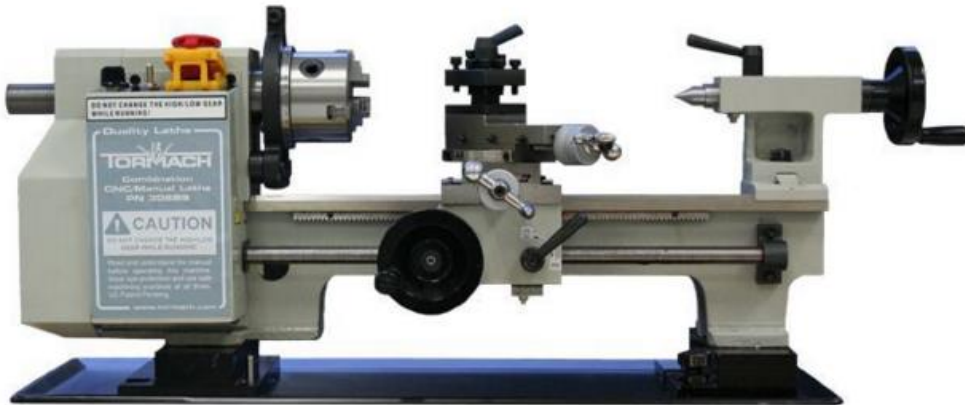
# MIG-Metal Inert Gas Welding

- Suitable for thicker cross-sections
- Widely used in Steel Constructions



# Turning

- The process in which the workpiece rotates



# Milling

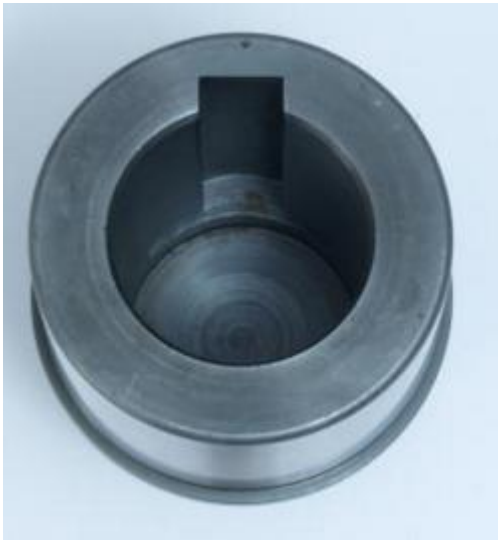
- The process in which the tool rotates



A little note: Do not forget the internal corner radii in your designs.



# Broaching

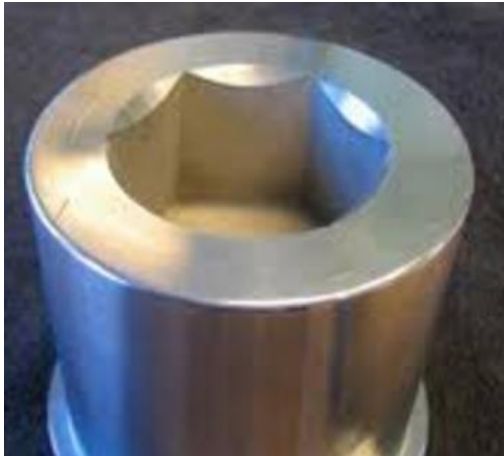


# Grinding

is an abrasive machining process which uses grinding wheel as cutting tool



# Die-Sink EDM

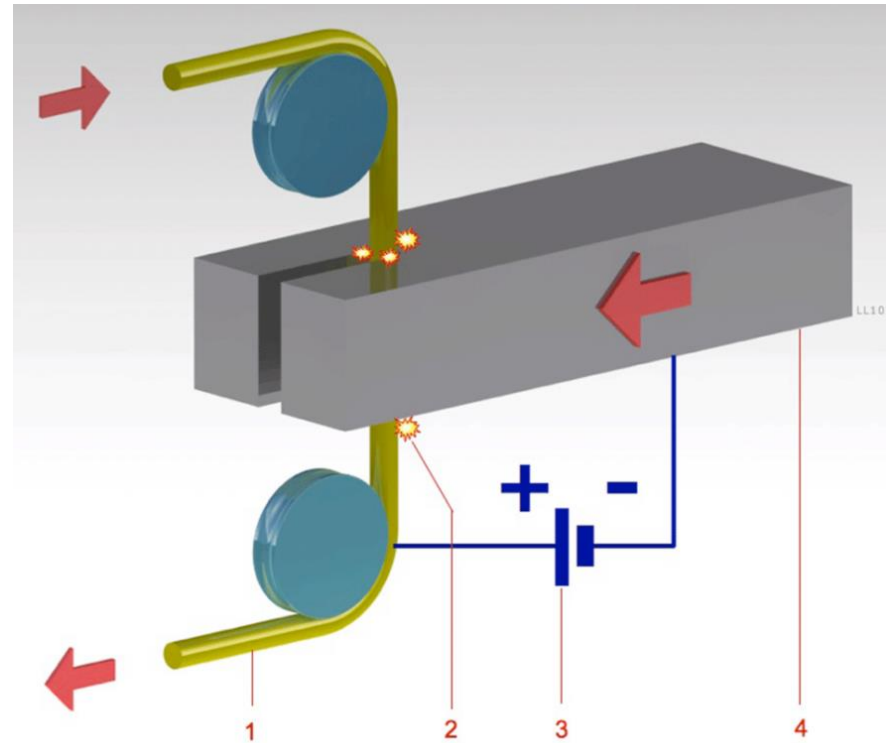
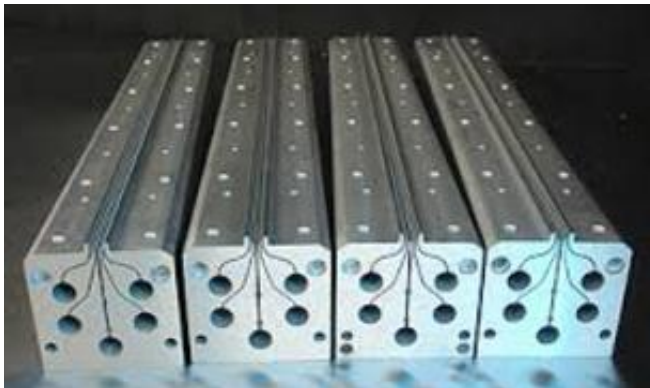


Note:

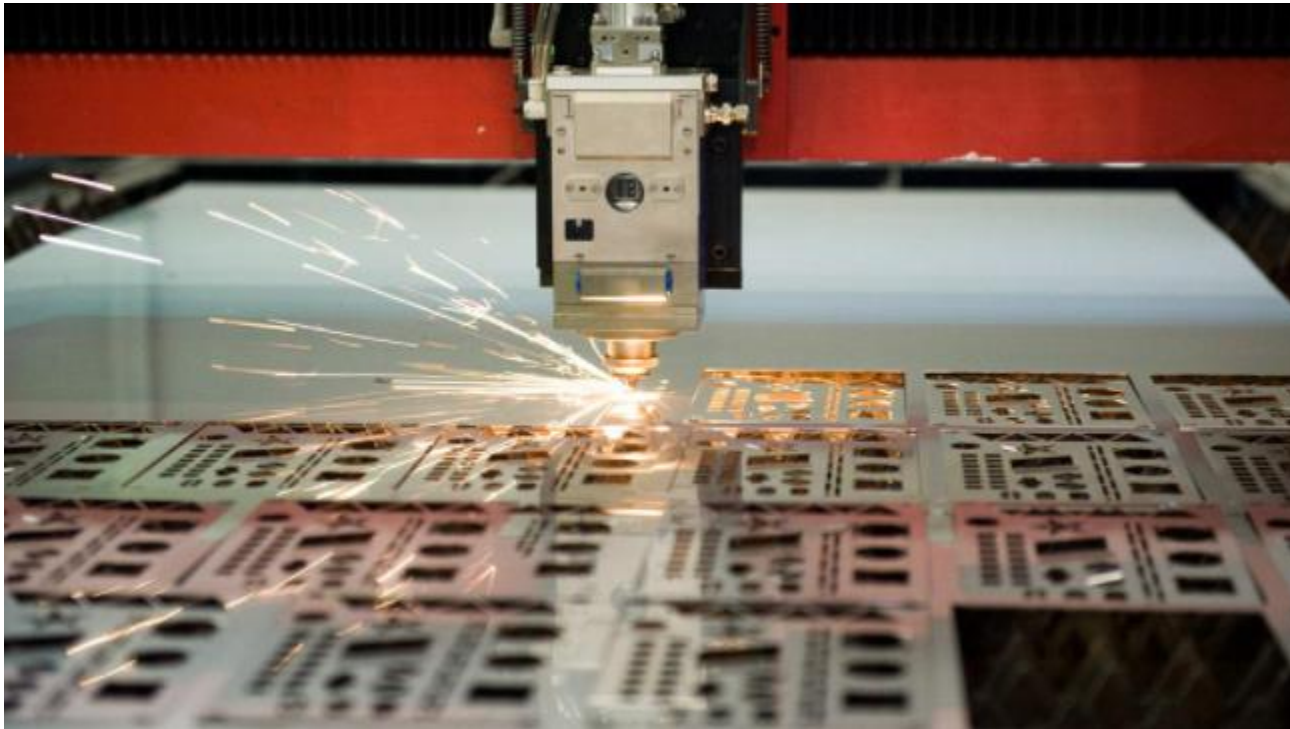
EDM is used mainly on heat treated steel parts with high hardness levels.



# Wire Cut EDM



# Laser Cutting



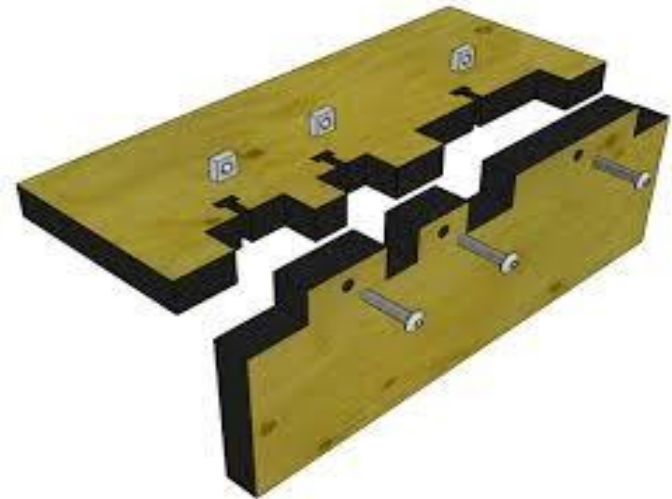
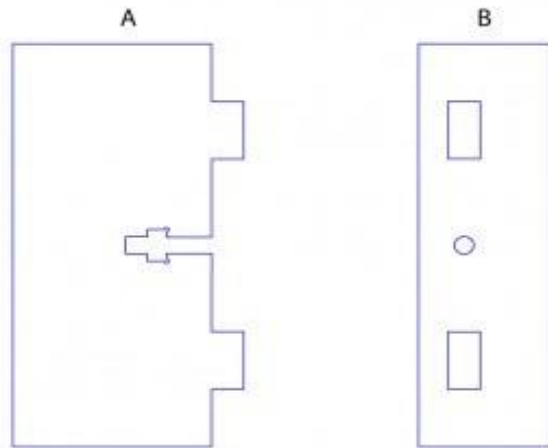
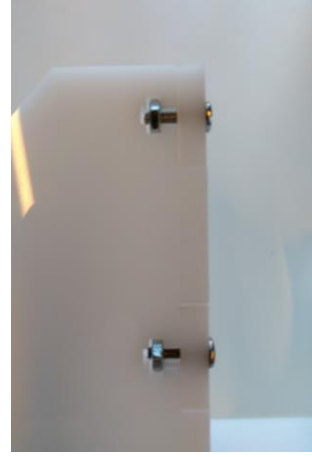
Metals: Steel, aluminium, brass etc.

Non Metals like Plexiglass, wood

COMMON MANUFACTURING PROCESSES

Sheet Metal

# Laser Cutting Example



T-Slot Joint,  
A sturdy structure design method based on sheet cutting

# Plasma Cutting



Only for steel

# Bending



Always check the unfolded dimensions with your bending-man before getting the parts cut. Don't trust your CAD software.



## **NEJAT ULUSAL**

Mechanical Engineer (M.Sc)

For further questions;  
[nejat@ulusalmakina.com](mailto:nejat@ulusalmakina.com)



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