

## Tutorial 48: Gear Pairings by Yannick Krieger

2020-09-09: Yannick Krieger, MIMED - Technische Universität München, Germany (URL: <http://www.SG-Lib.org>) - Last Change: 2020-09-15

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### Complete List of all Tutorials with Publishable MATLAB Files of this Solid-Geometries Toolbox

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The following topics are covered and explained in the specific tutorials:

- Tutorial 01: First Steps Using the VLFL-Toolbox for Solid Object Design
- Tutorial 02: Using the VLFL-Toolbox for STL-File Export and Import
- Tutorial 03: Closed 2D Contours and Boolean Operations in 2D
- Tutorial 04: 2½D Design Using Boolean Operators on Closed Polygon Lists (CPL)
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- Tutorial 06: Relative Positioning and Alignment of Solid Geometries (SG)
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- Tutorial 08: Slicing, Closing, Cutting and Separation of Solid Geometries
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- Tutorial 10: Packaging of Sets of Solid Geometries (SG)
- Tutorial 11: Attaching Coordinates Frames to Create Kinematik Models
- Tutorial 12: Define Robot Kinematics and Detect Collisions
- Tutorial 13: Mounting Faces and Conversion of Blocks into Lightweight-structures
- Tutorial 14: Manipulation Functions for Closed Polygons and Laser Cutting (SVG)
- Tutorial 15: Create a Solid by 2 Closed Polygons
- Tutorial 16: Create Tube-Style Solids by Succeeding Polygons
- Tutorial 17: Filling and Bending of Polygons and Solids
- Tutorial 18: Analyzing and modifying STL files from CSG modeler (Catia)
- Tutorial 19: Creating drawing templates and dimensioning from polygon lines
- Tutorial 20: Programmatically Interface to SimMechanics Multi-Body Toolbox
- Tutorial 21: Programmatically Convert Joints into Drives (SimMechanics)
- Tutorial 22: Adding Simulink Signals to Record Frame Movements
- Tutorial 23: Automatic Creation of a Missing Link and 3D Print of a Complete Model
- Tutorial 24: Automatic Creation of a Joint Limitations
- Tutorial 25: Automatic Creation of Video Titels, Endtitels and Textpages
- Tutorial 26: Create Mechanisms using Universal Planar Links
- Tutorial 27: Fourbar-Linkage: 2 Pose Syntheses and Linkage Export for 3D Printing
- Tutorial 28: Fourbar-Linkage: 3 Pose Syntheses and Linkage Export for 3D Printing
- Tutorial 29: Create a multi body simulation using several mass points
- Tutorial 30: Creating graphical drawings using point, lines, surfaces, frames etc.
- Tutorial 31: Importing 3D Medical DICOM Image Data and converting into 3D Solids
- Tutorial 32: Exchanging Data with a FileMaker Database
- Tutorial 33: Using a Round-Robin realtime multi-tasking system
- Tutorial 34: 2D Projection Images and Camera Coordinate System Reconstruction
- Tutorial 35: Creation of Kinematic Chains and Robot Structures
- Tutorial 36: Creating a Patient-Individual Arm-Skin Protector-Shell
- Tutorial 37: Dimensioning of STL Files and Surface Data
- Tutorial 38: Some more solid geometry modelling function
- Tutorial 39: HEBO Modules robot design
- Tutorial 40: JACO Robot Simulation and Control

- Tutorial 41: Inserting Blades, Cuts and Joints into Solid Geometries
- Tutorial 42: Performing FEM Stress and Displacement Analysis and Structural Optimization of Solids
- Tutorial 43: Performing FEM Structural Optimization (CAO) and Topological Optimization (SKO) of Solids
- Tutorial 44: Creation of solids and kinematics from 3D curves and transformation matrices
- Tutorial 45: Creation of Solids using the SG-Coder - SGofCPLcommand
- Tutorial 46: Creating Fischertechnik compatible gear boxes using SGofCPLcommand
- Tutorial 47: Create a Solid by two arbitrary CPLs and a distance
- Tutorial 48: Gear Pairings by Yannick Krieger
- Tutorial 50: CVLof2CPLzcorrelate and SGof2CPLzcorrelate
- Tutorial 51: Creating Parallel Tasks for batch processing
- Tutorial 52: CPL Buffers and cw/ccw Orientation
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- Tutorial 56: Checking Functions for Solids
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- Tutorial 58: Integrating joints into solids
- Tutorial 59: Integrating arbitrary joints into solids
- Tutorial 60: Facet generation for arbitrary contours in 3D space

### Motivation for this tutorial: (Originally SolidGeometry 5.0 required)

Based on my semester thesis written 2013, I tried to implement a function for the design of gear pairs. Basic Input is the distance and angle between the axis and the gear ratio. The function uses the subfunctions for the geometric design of spur gears, internal gears, bevel gears, crown wheels and gear racks.

### List of function introduced in this tutorial

- SGgearpair - Generates a gear pair
- SGgearSpur - Design of a spur gear
- SGgearInternal - Design of an internal gear
- SGgearRack - Design of a gear rack
- SGgearBevel - Design of a bevel gear
- SGgearCrownwheel - Design of a crown wheel

### Introduction of the function SGgearpair

Overview of the paramters

```
function VLFL_EXP48
```

```
help SGgearpair
```

```
SGgearpair(A,i,sigma,h,di,type) - returns a combination of two gears
(by Yannick Krieger, VLFL-Lib, 2020-SEP-16 as class: PARAMETRIC DESIGN)
First created on 2020-SEP-10 this fnctn has been added now to the SG-Lib
```

```
This fnctn creates single stage gear. The fnctn contains spur gears,
internal gears, bevel gears and crownwheels. The smaller gear is
defined with 14 teeth to avoid undercuts due to gear motion. (Status
of: 2020-09-16)
```

```
See also: VLFL_EXP48, SGgearSpur, SGgearInternal, SGgearRack,
SGgearBevel, SGgearCrownwheel, SGgearandrackDIN, SGgearwormDIN,
SGgearrackDIN, SGgearpairDIN, SGgearDIN, PLgearDIN, PLgearrackDIN
```

```
[SGgp,SGg1,SGg2]=SGgearpair([A,i,sigma,h,di,type])
```

```
=== INPUT PARAMETERS ===
```

```
A:      Shaft center distance as sum of the two radii, default is 20 [mm]; Give positive value for spur gear pair and negative value for gear p
i:      Gear ratio, default is 2.5 []; Has to be divisible by 0.5! Negative value defines a combination of spur gear and gear rack
sigma:  Angle between the axis, default is 0 [°]; A value of -90 defines a crownwheel
h:      Height of the gears, default is 3 [mm]
di:     Diameter of an inner bore hole, default is 0 [mm]
type:   Flag for the design of helical ('h') or herring bone ('v') teeth, default is '' ['string']
```

```
=== OUTPUT RESULTS =====
```

```
SGgp:   Pair of gears for the gear stage [SGT]
SGg1:   First gear of the pair as single SGT [SGT]
SGg2:   Second gear of the pair as single SGT [SGT]
```

```
EXAMPLE:
```

```
SGgearpair(20,2.5,0,3,0,'') %spur gears stage
SGgearpair(-20,2.5,0,3,0,'') %internal gear stage
SGgearpair(20,2.5,90,5,2,'v') %bevel gear stage
SGgearpair(20,2.5,-90) %gear stage with crown wheel
SGgearpair(20,-1.5,0,3,0,'h') %gear rack with spur gear
```

```
See also: VLFL_EXP48, SGgearSpur, SGgearInternal, SGgearRack,
SGgearBevel, SGgearCrownwheel, SGgearandrackDIN, SGgearwormDIN,
```

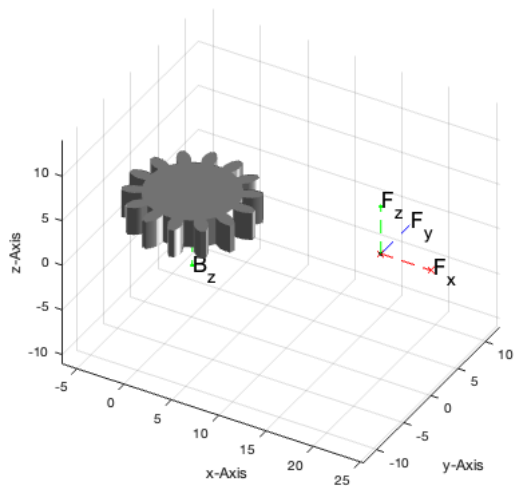
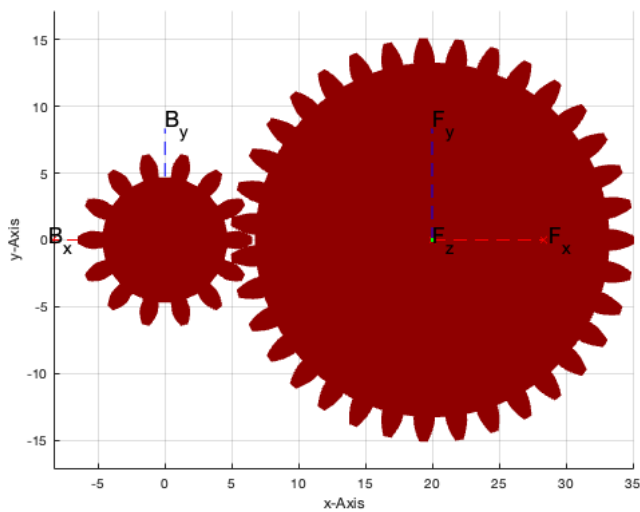
SGgearrackDIN, SGgearpairDIN, SGgearDIN, PLgearDIN, PLgearrackDIN

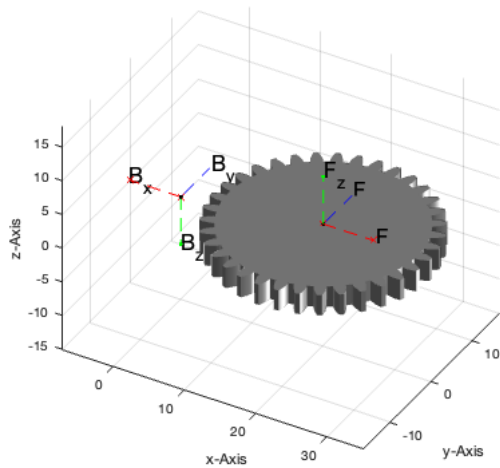
### Design of a gear pair consisting of two spur gears

Example1: Shaft center distance between the two axis is  $A=20\text{mm}$ , gear ratio is  $i=2.5$ , angle between the axis is  $\sigma=0^\circ$ , height of the gears is  $h=3\text{mm}$ , no bore hole is generated ( $d_i=0\text{mm}$ ) and straight gears are generated ( $\text{type}=""$ )

```
[SGgp,SGg1,SGg2] = SGgearpair(20,2.5,0,3,0,''); figure; SGTplotalpha(SGgp); figure; SGTplotalpha(SGg1); view(30,35); figure; SGTplotalpha(SGg2);view(30
```

SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaWarning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.  
 SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
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 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.



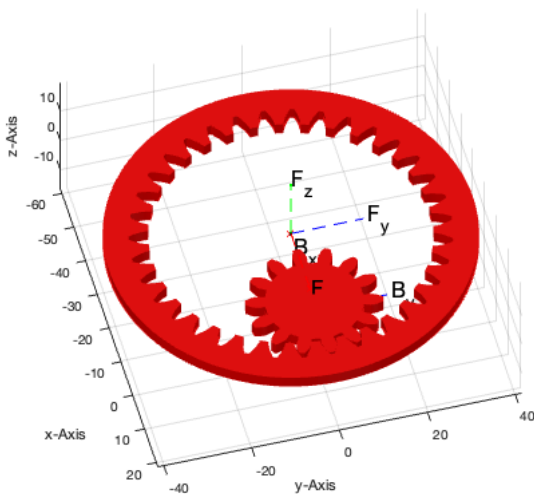


**Design of a gear pair consisting of one internal gear and one spur gear**

Negative shaft center distance between the two axis defines internal gear! Example 2: Shaft center distance between the two axis is  $A=-20\text{mm}$ , gear ratio is  $i=2.5$ , angle between the axis is  $\sigma=0^\circ$ , height of the gears is  $h=3\text{mm}$ , no bore hole is generated ( $d_i=0\text{mm}$ ) and straight gears are generated ( $\text{type}=""$ )

```
cla; [SGgp,SGg1,SGg2] = SGgearpair(-20,2.5,0,3,0,''); SGTplotalpha(SGgp);view(75,50);
```

SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.  
 delaunayWarning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.

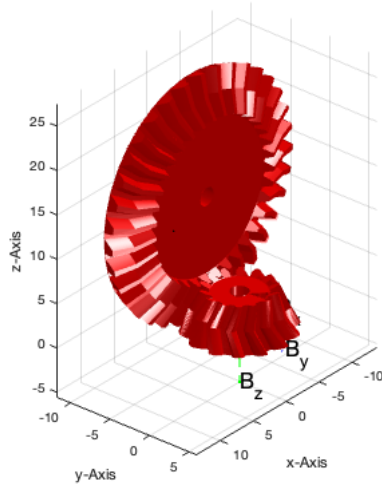


**Design of a gear pair consisting of two bevel gears with herring bone gears**

Angle  $\sigma$  is the angle between the two gear axis! Example 3: Shaft center distance between the two axis is  $A=20\text{mm}$ , gear ratio is  $i=2.5$ , angle between the axis is  $\sigma=90^\circ$ , height of the gears is  $h=5\text{mm}$ , a bore hole is generated with a diameter of  $d_i=2\text{mm}$  and herring bone gears are generated ( $\text{type}='v'$ )

```
cla;[SGgp,SGg1,SGg2] = SGgearpair(20,2.5,90,5,2,'v'); SGTplotalpha(SGgp);view(130,30)
```

SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.  
 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95% 100%Warning: Duplicate data points have been detected and removed.  
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 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90%Warning: Duplicate data points have been detected and removed.  
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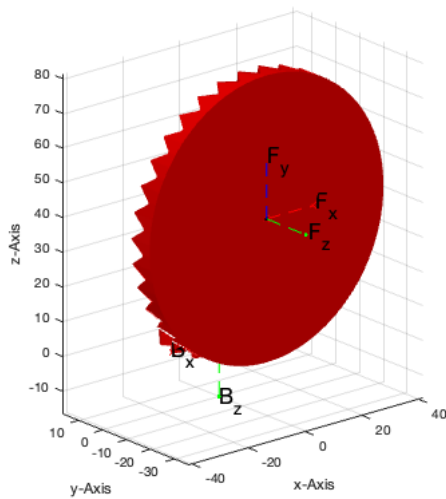


**Design of a gear pair consisting of one crown wheel and one spur gear**

A value of  $\sigma = -90^\circ$  for the angle between the two gear axis defines a crown wheel! Example 4: Shaft center distance between the two axis is  $A = 20\text{mm}$ , gear ratio is  $i = 2.5$ , angle between the axis is  $\sigma = -90^\circ$ , which defines the design of a crown wheel.

```
cla;[SGgp,SGg1,SGg2] = SGgearpair(20,2.5,-90); SGTplotalpha(SGgp); view(-40,20)
```

SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaWarning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.  
 SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaWarning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.

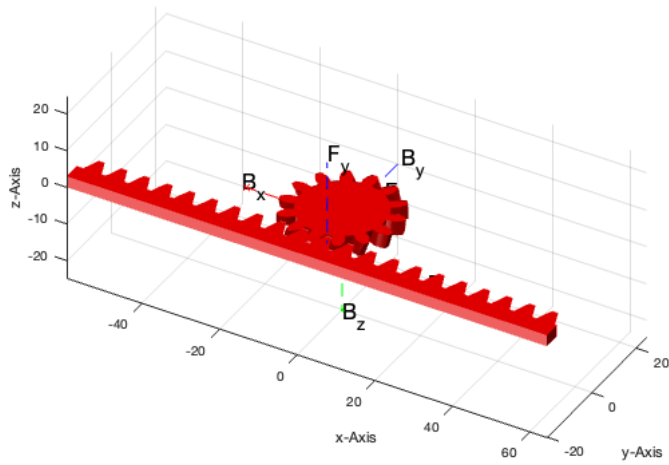


**Design of a gear pair consisting of one gear rack and one spur gear**

A negative value for the gear ratio ( $i < 0$ ) defines the design of a gear rack! Example 5: Distance between axis of the spur gear and the base of the gear rack is  $A = 20\text{mm}$ , gear ratio is  $i = -1.5$ , which defines the design of a gear rack. The angle between the axis is  $\sigma = 0^\circ$ . No bore hole is generated ( $d_i = 0\text{mm}$ ) and helical teeth are generated ( $\text{type} = 'h'$ )

```
cla;[SGgp,SGg1,SGg2] = SGgearpair(20,-1.5,0,3,0,'h'); SGTplotalpha(SGgp); view(30,35)
```

SGremsurfedgepoints:Warning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaWarning: Duplicate data points have been detected and removed.  
 The Triangulation indices and constraints are defined with respect to the unique set of points in delaunayTriangulation.



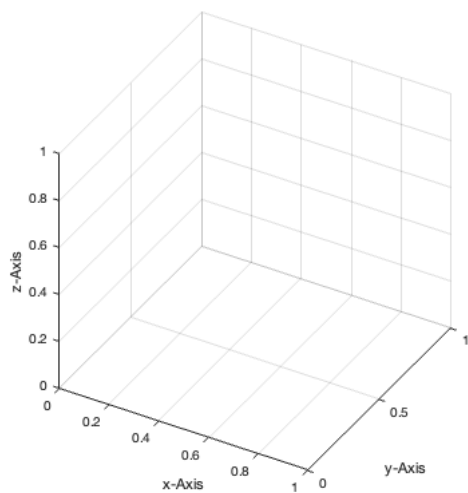
### Design of a spur gear as example

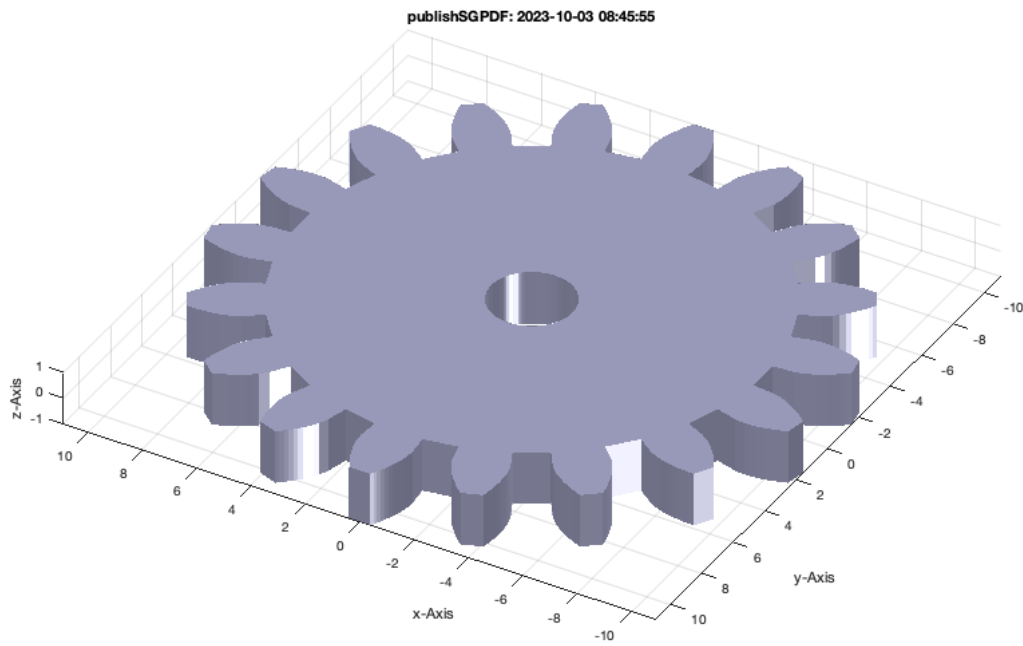
Specific parameters can be found in the help text.

```
cla; SGgearSpur; SGplotalpha(ans, 'w'); view(-150,35)
```

```
ans =
  Patch with properties:
    FaceColor: 'flat'
    FaceAlpha: 0.9000
    EdgeColor: 'none'
    LineStyle: '-'
    Faces: [3456x3 double]
    Vertices: [1732x3 double]

Use GET to show all properties
```

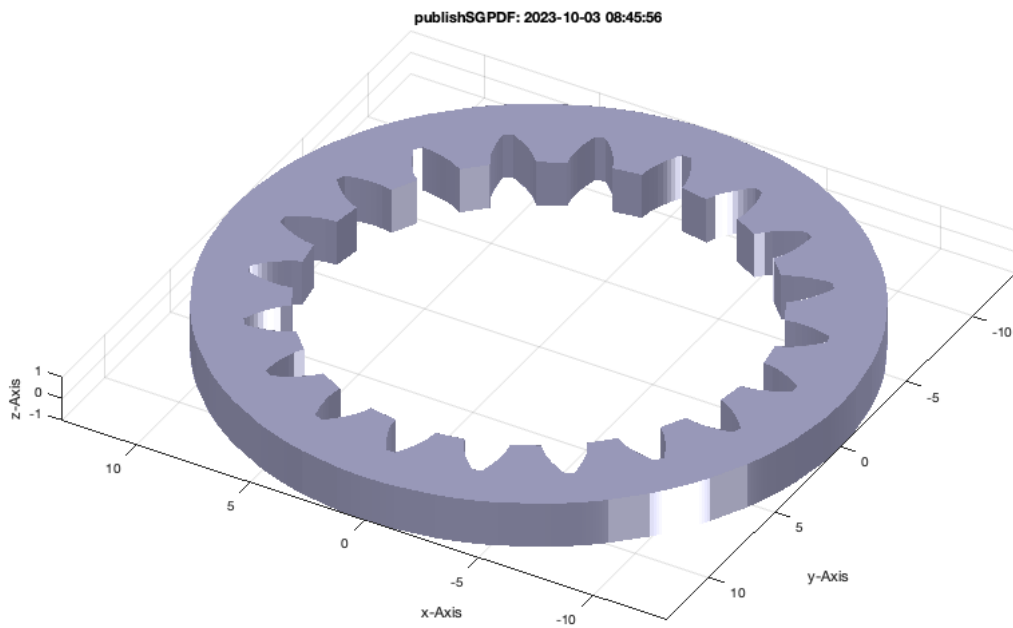




### Design of an internal gear as example

Specific parameters can be found in the help text.

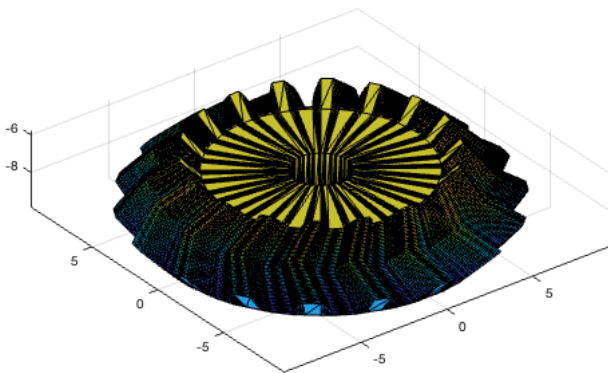
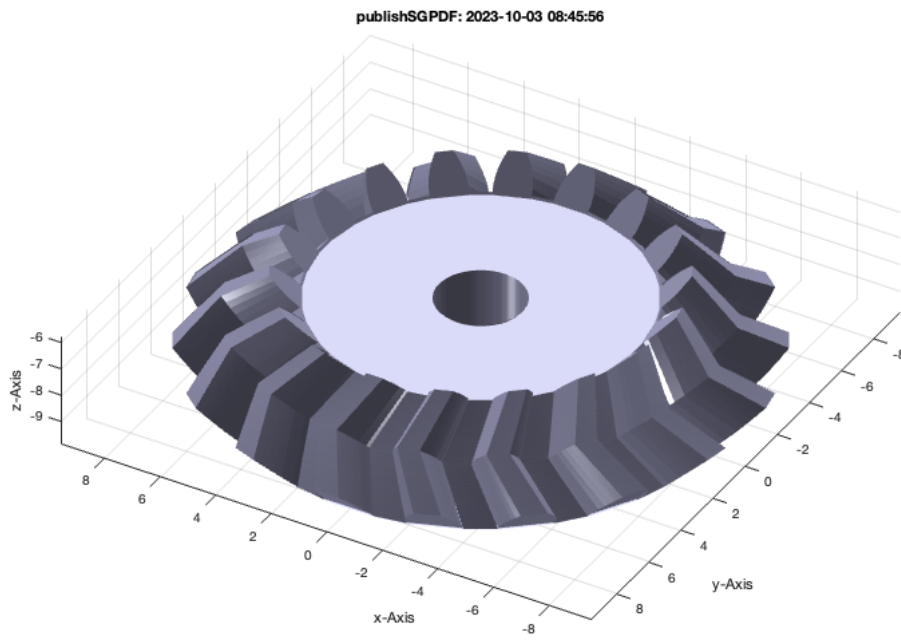
```
cla; SGgearInternal; SGplotalpha(ans,'w'); view(-150,35)
```



### Design of a bevel gear as example

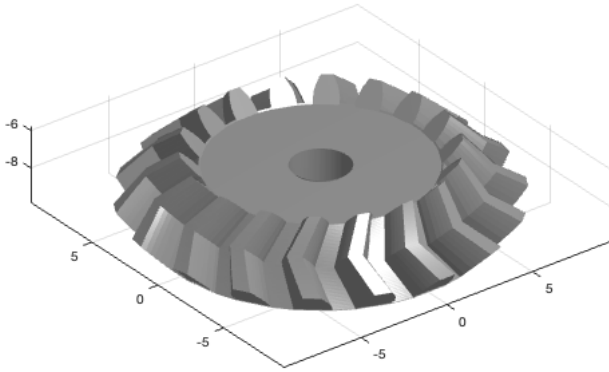
Specific parameters can be found in the help text.

```
cla; SG=SGgearBevel; SGplotalpha(SG,'w'); view(-150,35)
t=triangulation(SG.FL,SG.VL);
figure; h=trisurf(t);axis equal; hold on;
```



```
camlight, set(h,'FaceColor','w'); set(h,'EdgeColor','none'); material metal
```

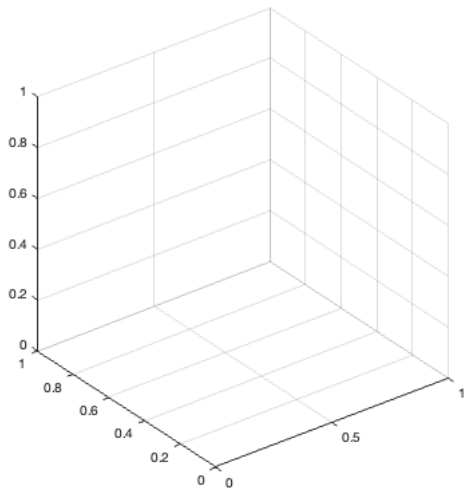


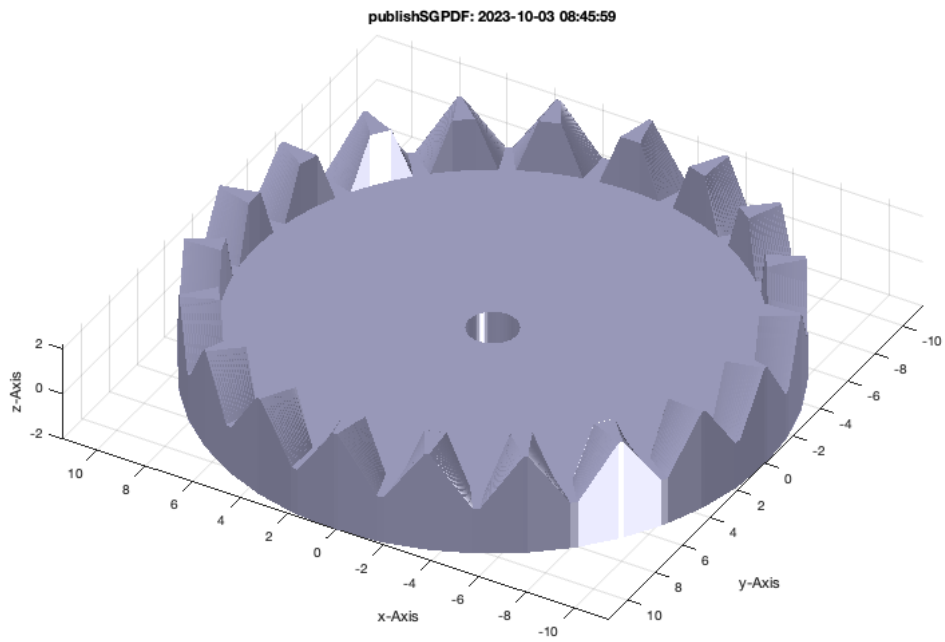


### Design of a crown wheel as example

Specific parameters can be found in the help text.

```
cla; SGgearCrownwheel; SGplotalpha(ans,'w'); view(-150,35)
```

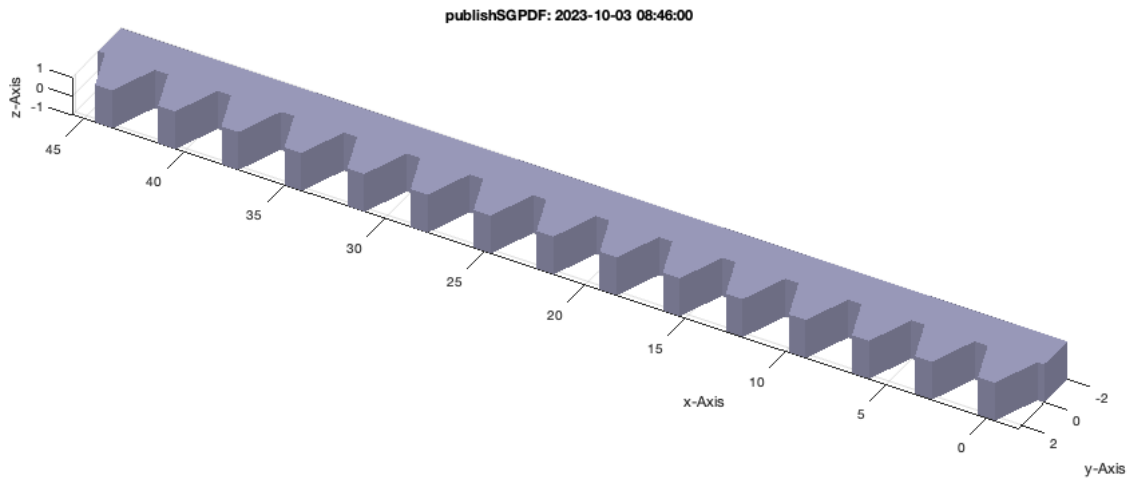




### Design of a gear rack as example

Specific parameters can be found in the help text.

```
cla; SGgearRack; SGplotalpha(ans, 'w'); view(-150,35)
```



### Final Remarks

```
close all
VLFLlicense
```

This VLFL-Lib, Rel. (2023-Oct-03), is for limited non commercial educational use only!  
 Licensee: Tim Lueth (Development Version)!  
 Please contact Tim Lueth, Professor at TU Munich, Germany!  
 WARNING: This VLFL-Lib (Rel. ) license will exceed at 06-Jul-2078 08:46:01!  
 Executed 03-Oct-2023 08:46:03 by 'timlueth' on a MACI64 using Mac OSX 13.6 | R2023a Update 5 | SG-Lib 5.4  
 ===== Used Matlab products: =====

```
database_toolbox
distrib_computing_toolbox
fixed_point_toolbox
image_toolbox
map_toolbox
matlab
optimization_toolbox
pde_toolbox
simmechanics
simscape
simulink
=====
```

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