Tutorial 54: Automated Design of Precision Joints by Screws or Ball Bearings

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

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Motivation for this tutorial: (Originally SolidGeometry 4.9 required)

```
dbprintf('The task of this tutorial is to show how to design revolute joints by screwing or ball bearings automatically.')

% function VLFL_EXP55
```

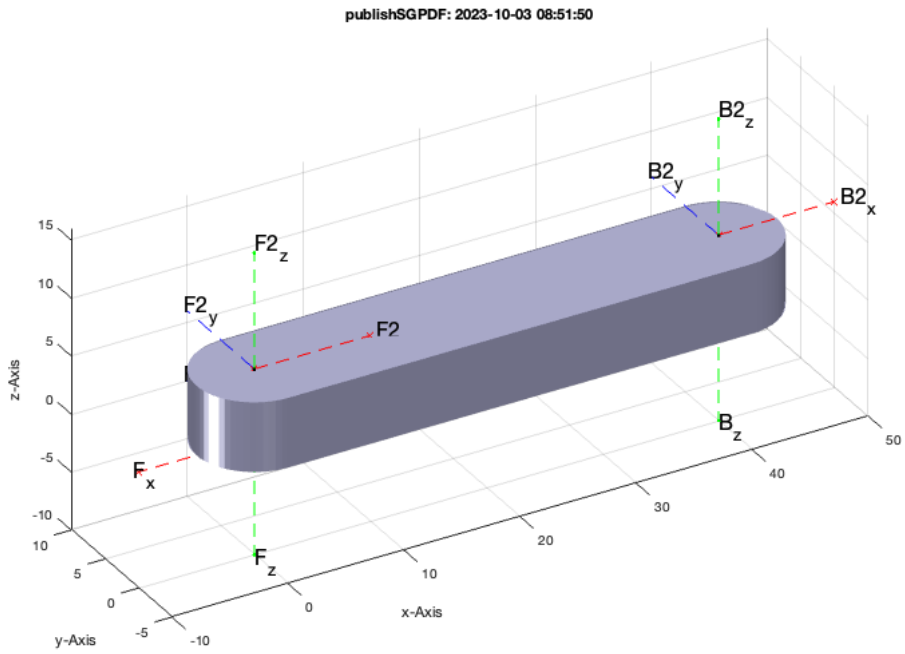
```
VLFL_EXP54: The task of this tutorial is to show how to design revolute joints by screwing or ball bearings automatically.
```

Design of a simple symmetrical mechanism link of length 4 including the frames for base and follower

Symmetrical joints are somewhat more appealing for the theoretical understanding

```
SGManipulatorLink(40,false); SG=ans
```

```
SG =
  struct with fields:

      VL: [132×3 double]
      FL: [260×3 double]
   Tname: {'F'  'B'  'F2'  'B2'}
       T: {[4×4 double]  [4×4 double]  [4×4 double]  [4×4 double]}
    TFiL: {[]  []  []  []}
```



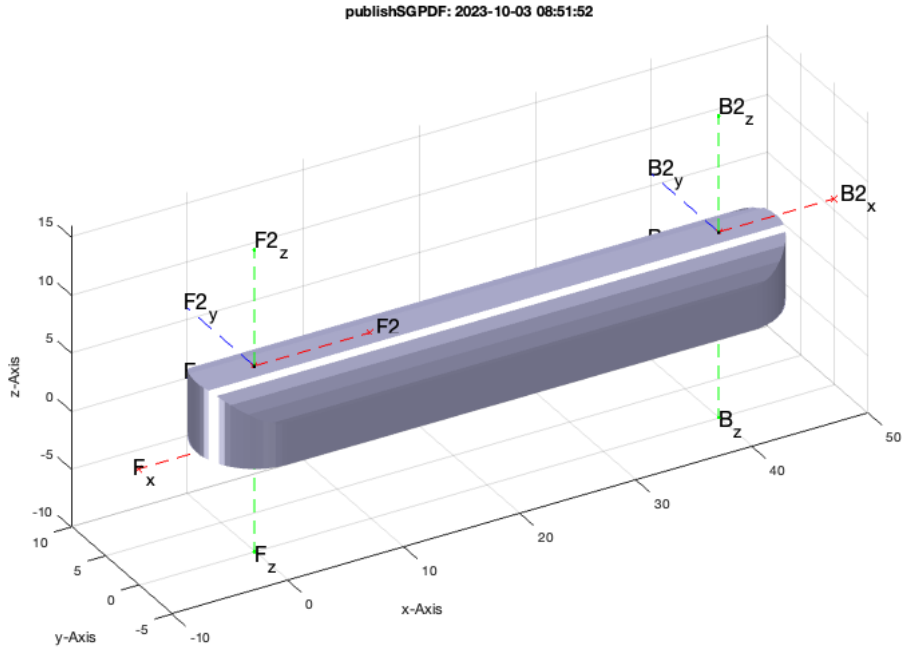
Design of a simple asymmetrical mechanism link of length 4 including the frames for base and follower

Unsymmetrical joints are only visually more appealing

```
SGManipulatorLink(40,true);  SG=ans
```

```
SG =
  struct with fields:

      VL: [194×3 double]
      FL: [384×3 double]
```

```
    FC: [384×3 double]
 Tname: {'F'  'B'  'F2'  'B2'}
     T: {[4×4 double]  [4×4 double]  [4×4 double]  [4×4 double]}
  TFiL: {[]  []  []  []}
```

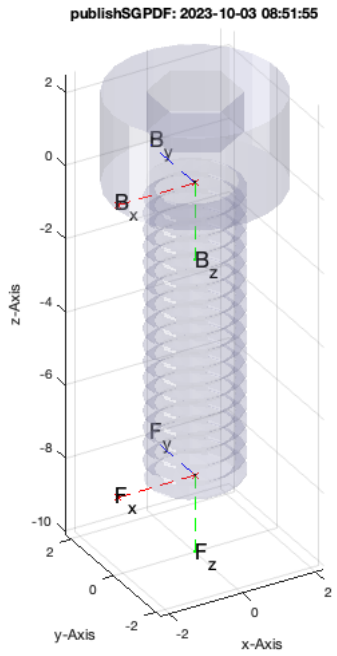


Design of a screw DIN 912 with M2.5 and length 8 =>

The screw is not printed, but bought as V2A screw for example from Wegertseder

```
SGDIN912(2.5,8); Screw=ans
```

```
Screw =
  struct with fields:

          VL: [1649×3 double]
          FL: [3294×3 double]
          FC: [3294×3 double]
       Tname: {'B'  'F'}
           T: {[4×4 double]  [4×4 double]}
        TFiL: {[]  []}
  stampname: 'DIN912 M2.5'
```

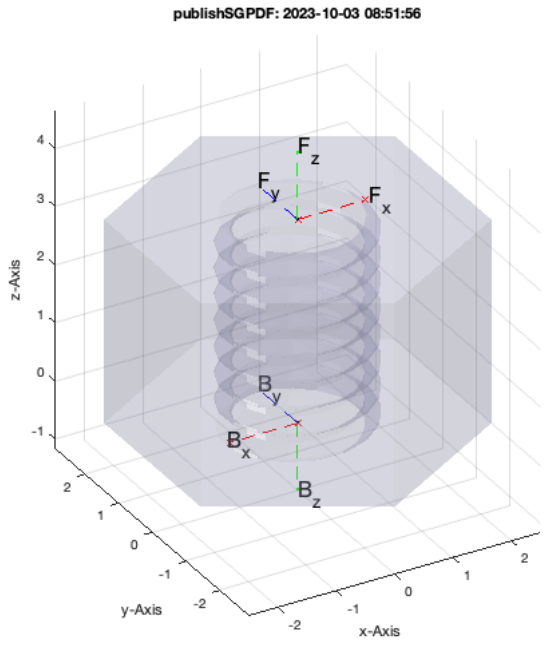


Design of a nut DIN 985 with M2.5 and length 8

The threaded nut is not printed, but bought as V2A screw for example from Wegertseder

```
SGDIN985(2.5); Nut=ans
```

```
Nut =
  struct with fields:

          VL: [759×3 double]
          FL: [1518×3 double]
       Tname: {'B'  'F'}
           T: {[4×4 double]  [4×4 double]}
        TFiL: {[]  []}
  stampname: 'DIN985 M2.5'
```



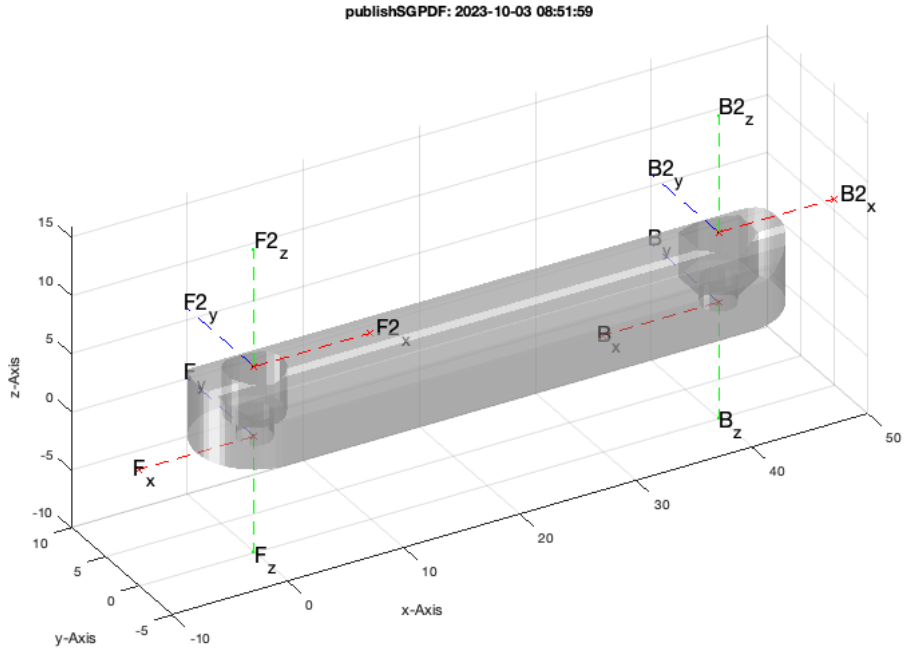
Realization of rotating joints by means of a screw connection DIN 912 and DIN 985

This function creates three solids

- H - Subtraction Screw Head side with frame 'C'
- N - Subtraction Screw Nut side with frame 'C'
- S - Model of a 912 screw and 985 Nut with frame 'C'

```
[H,N,S]=SGdesignDIN912DIN985([2.5 8],'TT',20);
SG=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
SG=SGsubtract(SG,N,'alignT',{'C','B'});    % Subtract the thread nut side

S1=SGtransrelSG(S,SG,'alignT',{'C','F'});  % Create a screw connection model on the head side
S2=SGtransrelSG(S,SG,'matchT',{'C','B'});  % Create a screw connection model on the threaded nut side

SGfigure; view(-30,30);
SGTplotalpha(SG); VLFLplotlight(1,0.5);
```

```
SGdesignDIN912DIN985: Creating Nut M2.5
SGdesignDIN912DIN985: Creating Screw M2.5 x 8mm
SGdesignDIN912DIN985: Creating Head Side Bore 2.5mm x 2.5mm
SGdesignDIN912DIN985: Creating Head Insertion Tunnel 2.5mm x 2.2mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 4.7mm x 10.6mm x 20mm
SGdesignDIN912DIN985: Creating Nut Side Bore 2.5mm x 6.0mm
SGdesignDIN912DIN985: Creating Nut Insertion Tunnel 5.0mm x 20.0mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 5.0mm x 3.9mm x 20mm
SGdesignDIN912DIN985: ============================================================
```



Realization of rotating joints by means of a screw connection DIN 912 (Tunnel) and DIN 985 (Pocket)

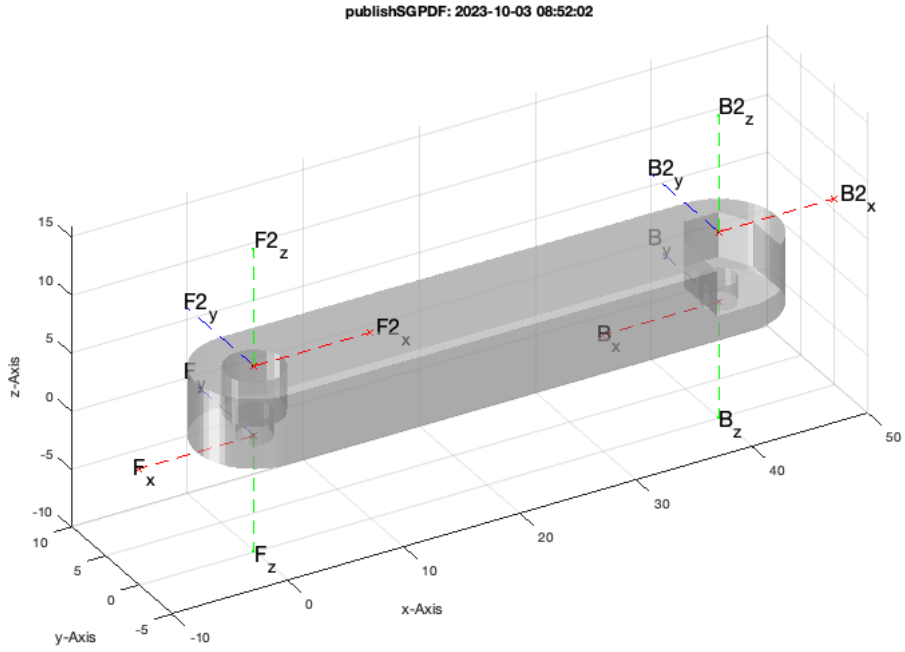
This function creates three solids

- H - Subtraction Screw Head side with frame 'C'
- N - Subtraction Screw Nut side with frame 'C' with a rotation of -pi/2
- S - Model of a 912 screw and 985 Nut with frame 'C'

```
SG=SGManipulatorLink(40,false);
[H,N,S]=SGdesignDIN912DIN985([2.5 8],'TP',20,-pi/2);
SG=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
SG=SGsubtract(SG,N,'alignT',{'C','B'});    % Subtract the thread nut side

S1=SGtransrelSG(S,SG,'alignT',{'C','F'});  % Create a screw connection model on the head side
S2=SGtransrelSG(S,SG,'matchT',{'C','B'});  % Create a screw connection model on the threaded nut side

SGfigure; view(-30,30);
SGTplotalpha(SG);  VLFLplotlight(1,0.5);
```

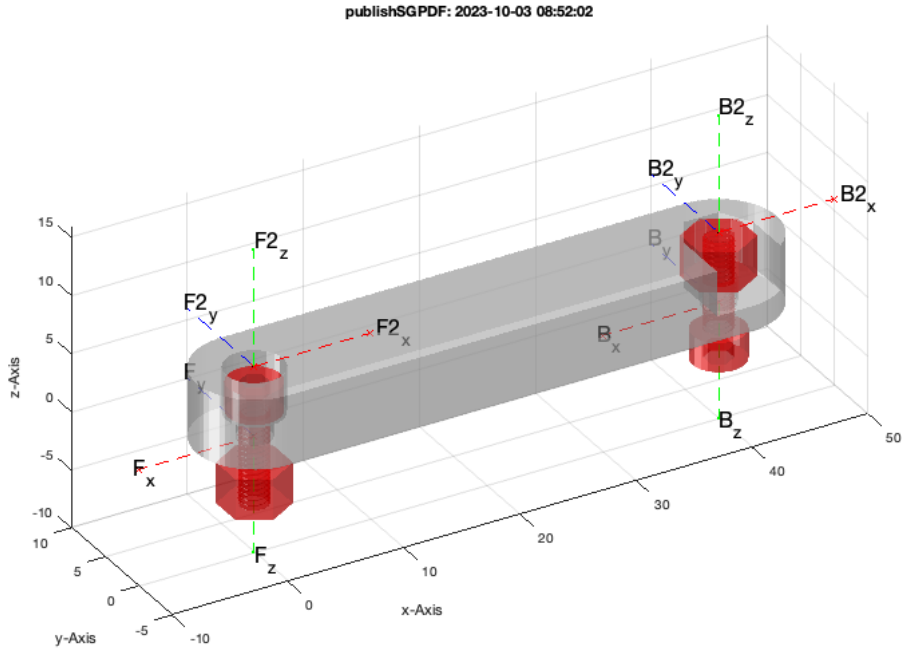
```
SGdesignDIN912DIN985: Creating Nut M2.5
SGdesignDIN912DIN985: Creating Screw M2.5 x 8mm
SGdesignDIN912DIN985: Creating Head Side Bore 2.5mm x 2.5mm
```

```
SGdesignDIN912DIN985: Creating Head Insertion Tunnel 2.5mm x 2.2mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 4.7mm x 10.6mm x 20mm
SGdesignDIN912DIN985: Creating Nut Side Bore 2.5mm x 6.0mm
SGdesignDIN912DIN985: Creating Nut Insertion Tunnel 5.0mm x 20.0mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 5.0mm x 3.9mm x 20mm
SGdesignDIN912DIN985: ======================================================
```



Now show also the screws

```
SGplotalpha(S1,'r');
SGplotalpha(S2,'r');
VLFLplotlight(1,0.5);
```

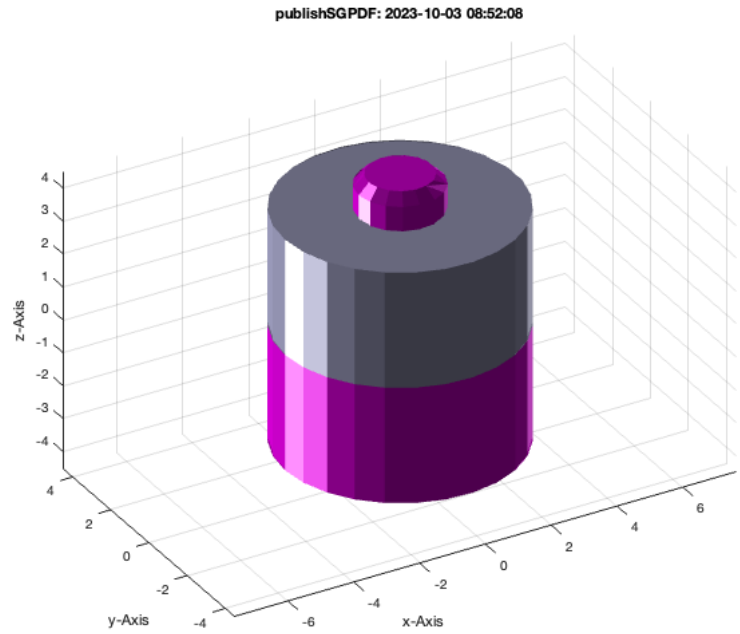


Realisation of a rotating joint with a ball bearing and a bearing stop of the same size

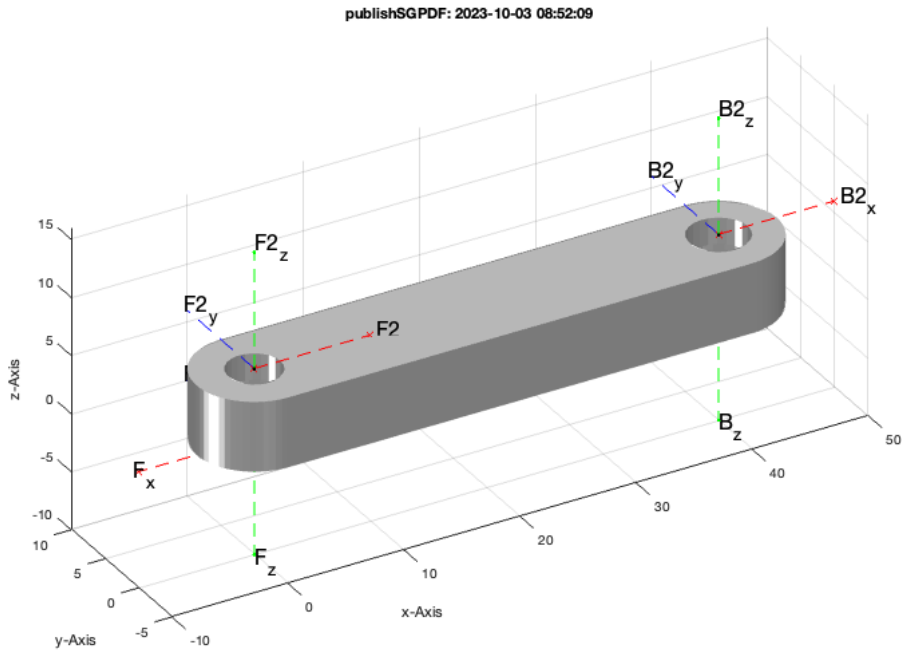
```
SG=SGManipulatorLink(40,false);
[H,N,S,B]=SGdesignBallbearing([2.5 7 3.5 1],'S',20);
SG=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
```

```
SG=SGsubtract(SG,N,'alignT',{'C','B'});    % Subtract the thread nut side

SGfigure; SGplotalpha(S,'m'); SGplotalpha(B,'w');  view(-30,30)
```

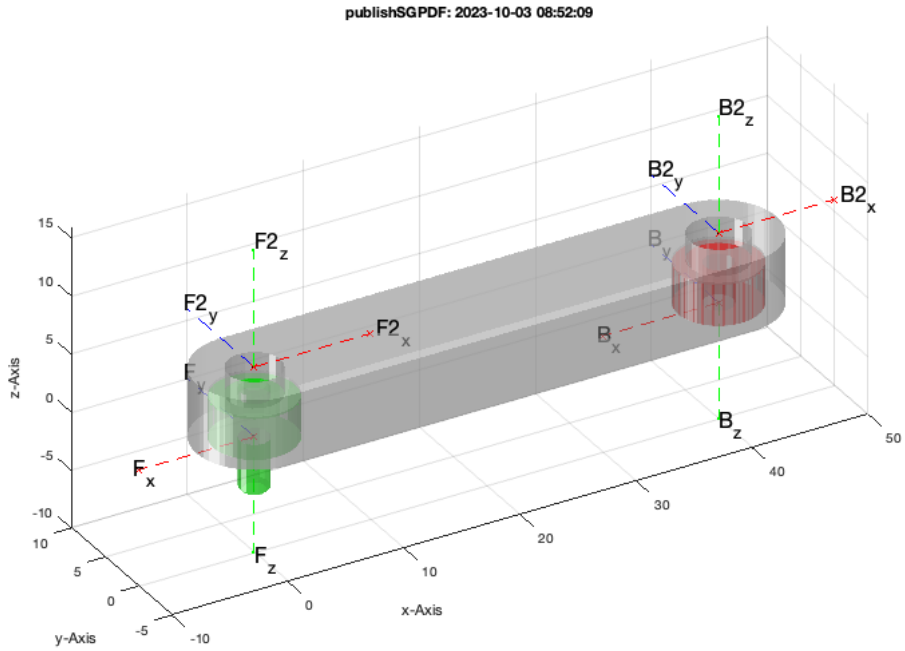
```
VLFLcorrectdoubledvertex: 2 Collapsed Facets
VLFLcorrectdoubledvertex: 2 Collapsed Facets
VLFLcorrectdoubledvertex: 3 Collapsed Facets
VLFLcorrectdoubledvertex: 1 Collapsed Facets
FLrepair: (SGremsurfedgepoints) 1 open triangle(s) closed.
FLrepair: (SGremsurfedgepoints) No open boundaries finally exist!
SGboolh: Solid B is not watertight
publishSGPDF:<a href = "matlab: openbydoubleclick ('/Users/timlueth/Desktop')">/Users/timlueth/Desktop/</a><a href = "matlab: openbydoubleclick ('/User
```




```
S1=SGtransrelSG(B,SG,'alignT',{'C','B'});  % Ball Bearing belongs to the nut or large bore position
S2=SGtransrelSG(S,SG,'matchT',{'C','F'});  % PLug Bearing belongs to the Screw or small bore position

SGfigure; view(-30,30);
SGplotalpha(SG); SGTframeplot(SG);
```



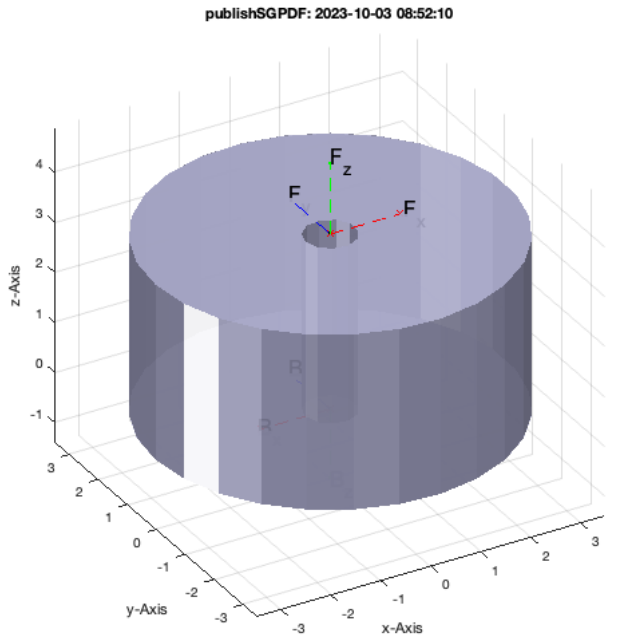

```
SGplotalpha(S1,'r'); SGplotalpha(S2,'g');VLFLplotlight(1,0.5);
```



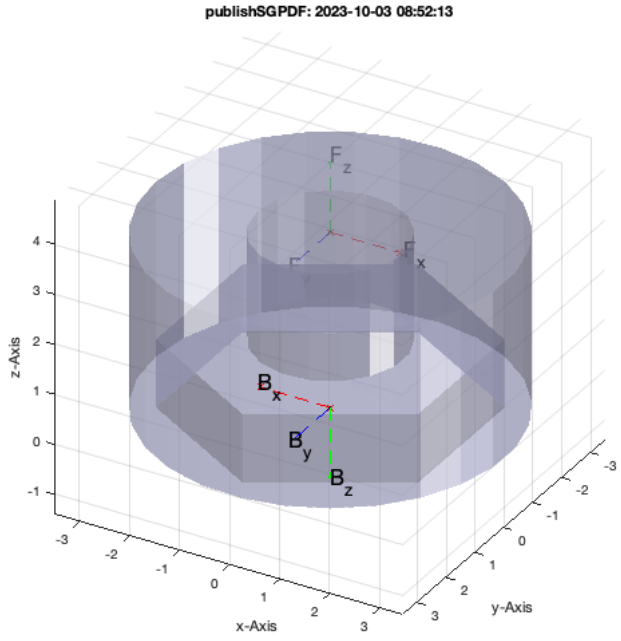
Create Plug to convert a Ball Bearing Solution into a screw fixing solution

```
SGbearing([1 7 3.5],'plug'); SG=SGunion(ans);   % This time the inner diameter must be smaller
[H,N,S]=SGdesignDIN912DIN985([2.5 8]);          % Prepare a screw connection
```

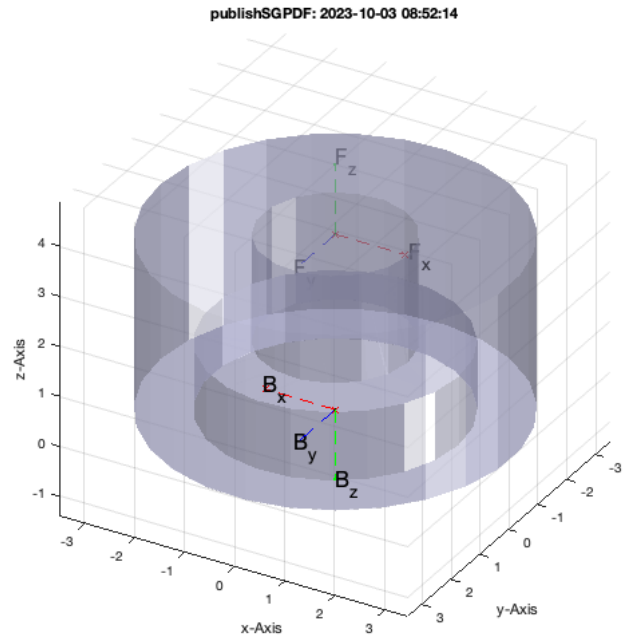
```
SGdesignDIN912DIN985: Creating Nut M2.5
SGdesignDIN912DIN985: Creating Screw M2.5 x 8mm
SGdesignDIN912DIN985: Creating Head Side Bore 2.5mm x 2.5mm
SGdesignDIN912DIN985: Creating Head Insertion Tunnel 2.5mm x 2.2mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 4.7mm x 10.6mm x 10mm
SGdesignDIN912DIN985: Creating Nut Side Bore 2.5mm x 6.0mm
SGdesignDIN912DIN985: Creating Nut Insertion Tunnel 5.0mm x 10.0mm
SGdesignDIN912DIN985: Creating Head Insertion Pocket 5.0mm x 3.9mm x 10mm
SGdesignDIN912DIN985: ========================================================
```




```
SN=SGsubtract(SG,N,'alignT',{'C','F'});    % Subtract the nut side
SGfigure; view(-30,-30); SGTplotalpha(SN,'w',0.5);
```



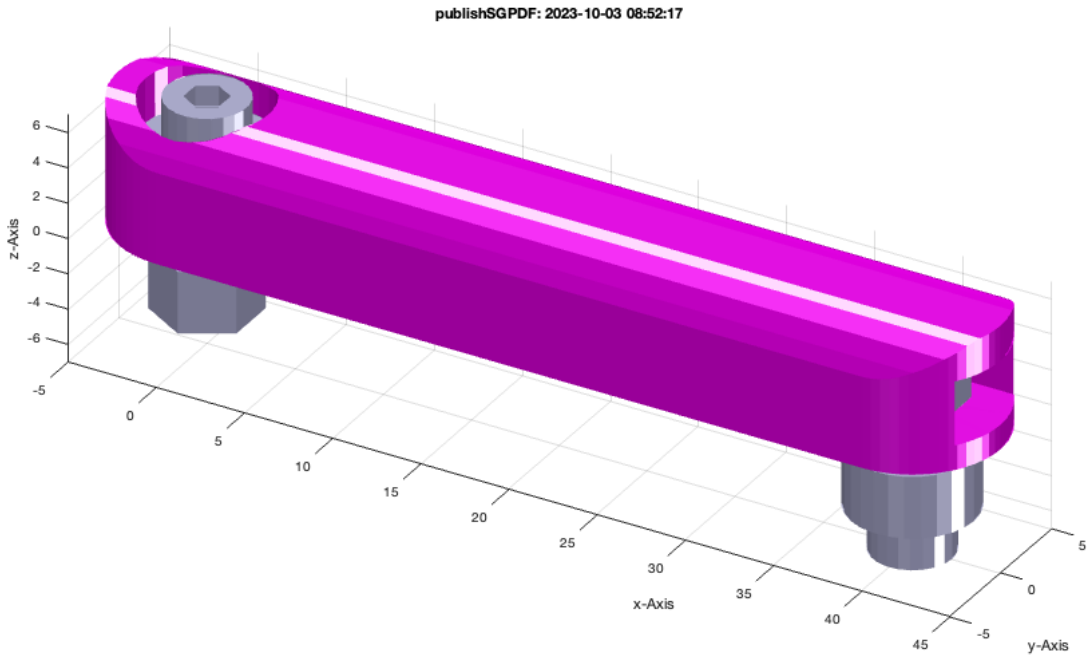

```
SH=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
SGfigure; view(-30,-30); SGTplotalpha(SH,'w',0.5);
```



Automated Design of a rotating joint with a ball bearing and a DIN912-985 fixation with a nut-pocket

```
SG=SGManipulatorLink(40,true,5,7);
[H,N,S]=SGdesignDIN912DIN985radialbearing([2.5 7 3.5],[9.5 0],'TP',20,-pi);
SGN=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
SGN=SGsubtract(SGN,N,'alignT',{'C','B'});    % Subtract the thread nut side

SGfigure; SGplotalpha(SGN,'m'); view(+30,30);
SGTplotalpha(S,'w','','',SGN,'matchT',{'C','B'});  SGTplotalpha(S,'w','','',SGN,'alignT',{'C','F'});
```

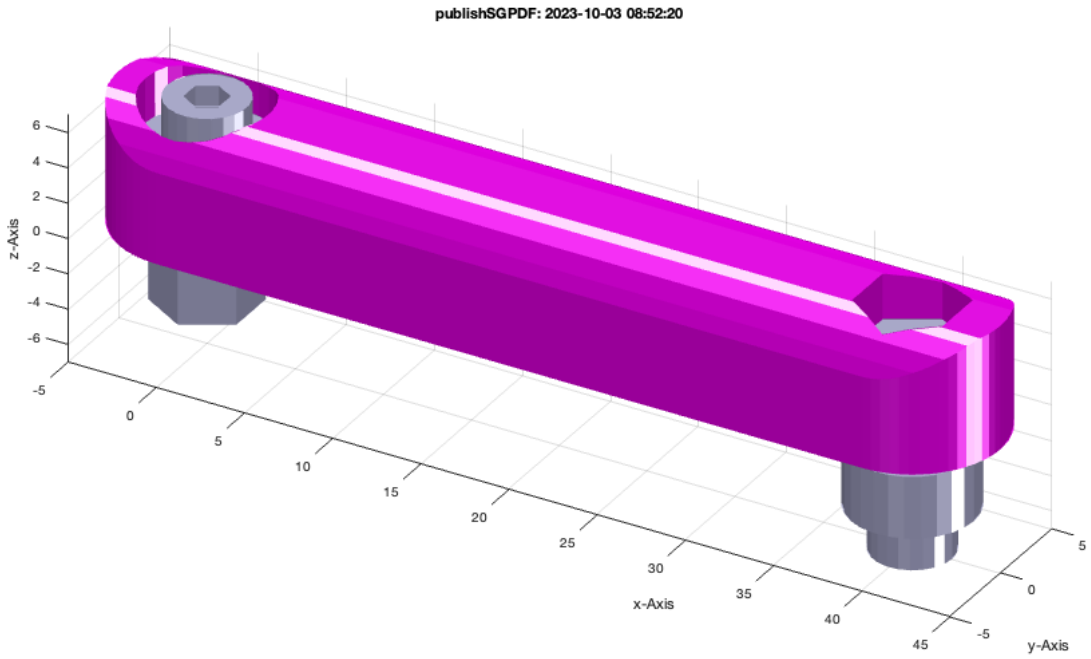
```
SGdesignDIN912DIN985radialbearing: Creating Nut M2.5
SGdesignDIN912DIN985radialbearing: Creating Screw M2.50 x 10mm
SGdesignDIN912DIN985radialbearing: Number of DIN433 washers for a minimal wall size 1.0mm is n=2
SGdesignDIN912DIN985radialbearing: The exact wall size on bearing size is: 1.0mm. The thread length on bearing side is 4.5mm
SGdesignDIN912DIN985radialbearing: Creating Head Side Bore 2.6mm x 1.2mm
SGdesignDIN912DIN985radialbearing: Creating Bearing Insertion Tunnel 2.50mm x 7.00mm
SGdesignDIN912DIN985radialbearing: Creating Head Insertion Pocket 4.6mm x 12.1mm x 20mm
SGdesignDIN912DIN985radialbearing: Creating Nut Side Bore 2.5mm x 5.2mm
SGdesignDIN912DIN985radialbearing: Creating Nut Insertion Tunnel 5.0mm x 20.0mm
SGdesignDIN912DIN985radialbearing: Creating Head Insertion Pocket 5.0mm x 3.6mm x 20mm
SGdesignDIN912DIN985radialbearing: ============================================================
```



Automated Design of a rotating joint with a ball bearing and a DIN912-985 fixation with a nut-tunnel

```
SG=SGManipulatorLink(40,true,5,7);
[H,N,S]=SGdesignDIN912DIN985radialbearing([2.5 7 3.5],[8  -1],'T',20);
SGN=SGsubtract(SG,H,'alignT',{'C','F'});    % Subtract the head side
SGN=SGsubtract(SGN,N,'alignT',{'C','B'});    % Subtract the thread nut side

SGfigure; SGplotalpha(SGN,'m'); view(+30,30);
SGTplotalpha(S,'w','','',SGN,'matchT',{'C','B'});  SGTplotalpha(S,'w','','',SGN,'alignT',{'C','F'});
SGwriteSTL(SGN)
```

```
SGdesignDIN912DIN985radialbearing: Creating Nut M2.5
SGdesignDIN912DIN985radialbearing: Creating Screw M2.50 x 8mm
SGdesignDIN912DIN985radialbearing: Number of DIN433 washers for a minimal wall size 1.0mm is n=2
SGdesignDIN912DIN985radialbearing: The exact wall size on bearing size is: 1.0mm. The thread length on bearing side is 4.5mm
SGdesignDIN912DIN985radialbearing: Creating Head Side Bore 2.6mm x 1.2mm
SGdesignDIN912DIN985radialbearing: Creating Bearing Insertion Tunnel 2.50mm x 7.00mm
SGdesignDIN912DIN985radialbearing: Creating Head Insertion Pocket 4.6mm x 10.6mm x 20mm
SGdesignDIN912DIN985radialbearing: Creating Nut Side Bore 2.5mm x 3.7mm
SGdesignDIN912DIN985radialbearing: Creating Nut Insertion Tunnel 5.0mm x 20.0mm
SGdesignDIN912DIN985radialbearing: Creating Head Insertion Pocket 5.0mm x 3.6mm x 20mm
SGdesignDIN912DIN985radialbearing: ======================================================
publishSGPDF:<a href = "matlab: openbydoubleclick ('/Users/timlueth/Desktop')">/Users/timlueth/Desktop/</a><a href = "matlab: openbydoubleclick ('/User
ans =
    '/Users/timlueth/Desktop/publishSGPDF SGN_(2023-10-03).STL'
```



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 08:52:21!
Executed 03-Oct-2023 08:52:23 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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