

Tutorial 43: Performing FEM Structural Optimization (CAO) and Topological Optimization (SKO) of Solids

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

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)
- Tutorial 05: Creation, Relative Positioning and Merging of Solid Geometries (SG)
- Tutorial 06: Relative Positioning and Alignment of Solid Geometries (SG)
- Tutorial 07: Rotation of Closed Polygon Lists for Solid Geometry Design
- Tutorial 08: Slicing, Closing, Cutting and Separation of Solid Geometries
- Tutorial 09: Boolean Operations with Solid Geometries
- 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

Motivation for this tutorial: (Originally SolidGeometry 4.2 required)

Yinlun Sun of TU Munich has supplemented the SG-Library with functions that allow a structural and topological optimization of geometric bodies with surface representation.

List of function introduced in this tutorial

```
% function VLFL_EXP43
% clear all; close all;
```

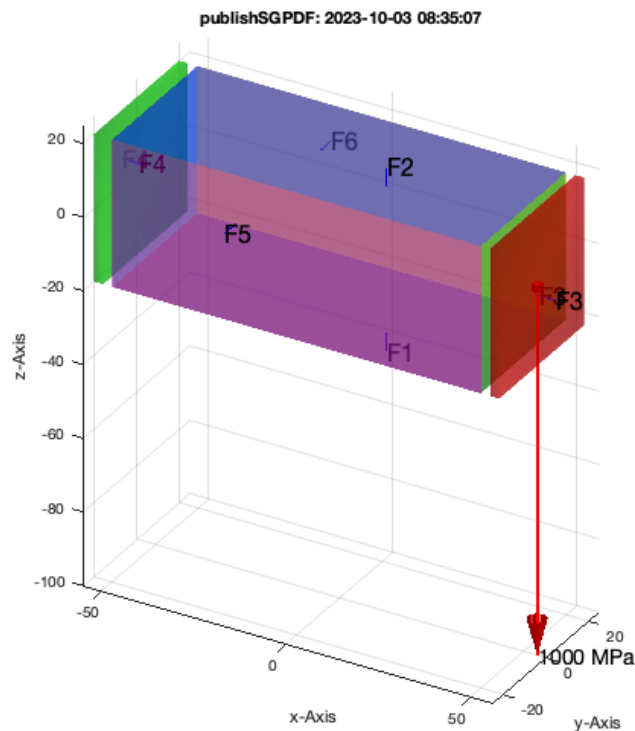
1. Conversion between triangle surface model and tetrahedon volumen model

1.1 Create a simple bar type link

```
A=SGbox([100,40,40])
SGfigure; FSplot(A); view(30,30);
SGplotsurfaceload (A, 'FixedFaceIndices',4, 'LoadFaceIndices',3, 'Load',[0 0 -1e3]);
```

```
A =
  struct with fields:

    VL: [8×3 double]
    FL: [12×3 double]
    Tname: {'B' 'F' 'X+' 'X-' 'Y+' 'Y-'}
    T: {1×6 cell}
    TFIL: {[ ] [ ] [ ] [ ] [ ] [ ]}
6 Feature Surfaces found! Only the largest 99.90% (4.000 .. 4000.0mm^2), i.e. 6 of 6 are shown.
```



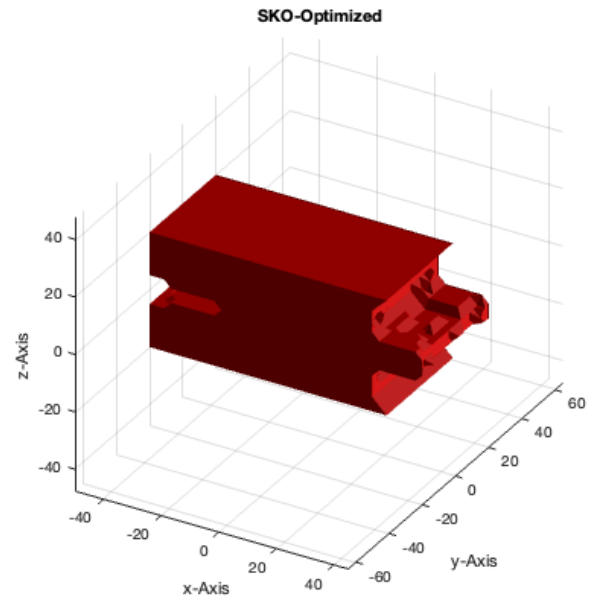
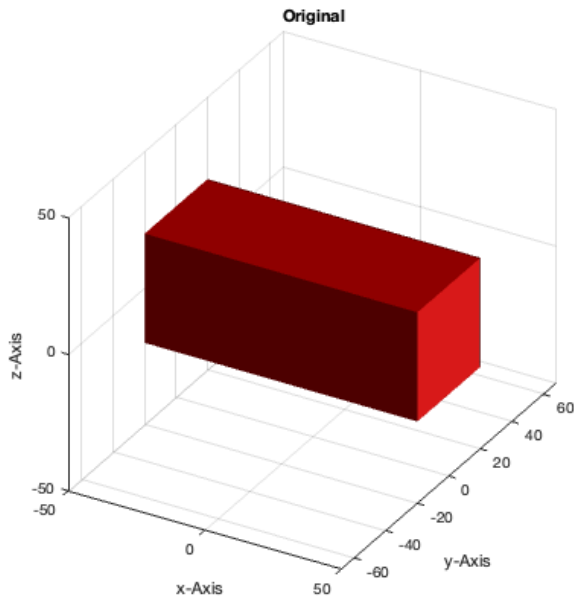
```
SGshapeOptiSKO(A, 'FixedFaceIndices',4, 'LoadFaceIndices',3, 'Load',[0 0 -1e3]); B=ans
```

```
Iteration 0: Average stress: 2.95, Maximum stress: 10.62
Iteration 1: Average stress: 2.95, Maximum stress: 10.73
Iteration 2: Average stress: 2.94, Maximum stress: 10.84
Iteration 3: Average stress: 2.94, Maximum stress: 10.95
```

```

Iteration 4: Average stress: 2.94, Maximum stress: 11.05
Iteration 5: Average stress: 2.94, Maximum stress: 11.16
Iteration 6: Average stress: 2.94, Maximum stress: 11.26
Iteration 7: Average stress: 2.94, Maximum stress: 11.36
Iteration 8: Average stress: 2.93, Maximum stress: 11.46
B =
struct with fields:
    VL: [3040x3 double]
    FL: [6066x3 double]
    pcon: 0.8000

```



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 08:35:55!

Executed 03-Oct-2023 08:35:57 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
pde_toolbox
simmechanics
simscape
simulink
=====

```