Tutorial 28: Fourbar-Linkage: 3 Pose Syntheses and Linkage Export for 3D Printing

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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 3.3 required)

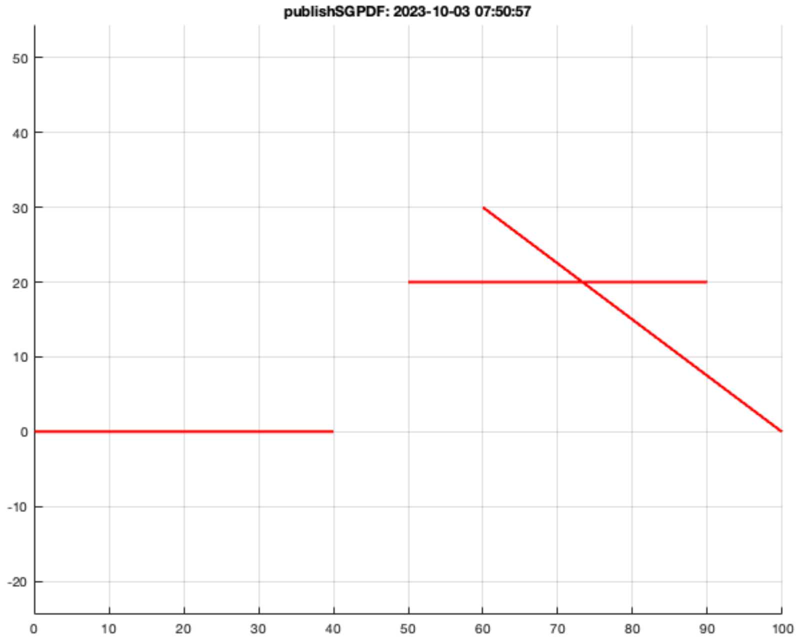
```
smbNewSystem ('SG_LIB_EXP_28',[+5 +5 +5]);           % Creates the mechansim diagramm
```

```
Creating temporary directory '/Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/'
```

3. Show a Two Pose Problem

Poses are described by the start point and end point of a link. The first point of the coupling defines a point, the second point also the direction. In the simplest case, two poses for the design of a four-bar are given.

```
d=[0 0];
C1=[ 0 0];
D1=[40 0];
C2=[60 30];
D2=[100 0];
C3=[90 20];
D3=[50 20];

SGfigure;
PLplot([C1;D1],'r-',2);
PLplot([C2;D2],'r-',2);
PLplot([C3;D3],'r-',2);
```

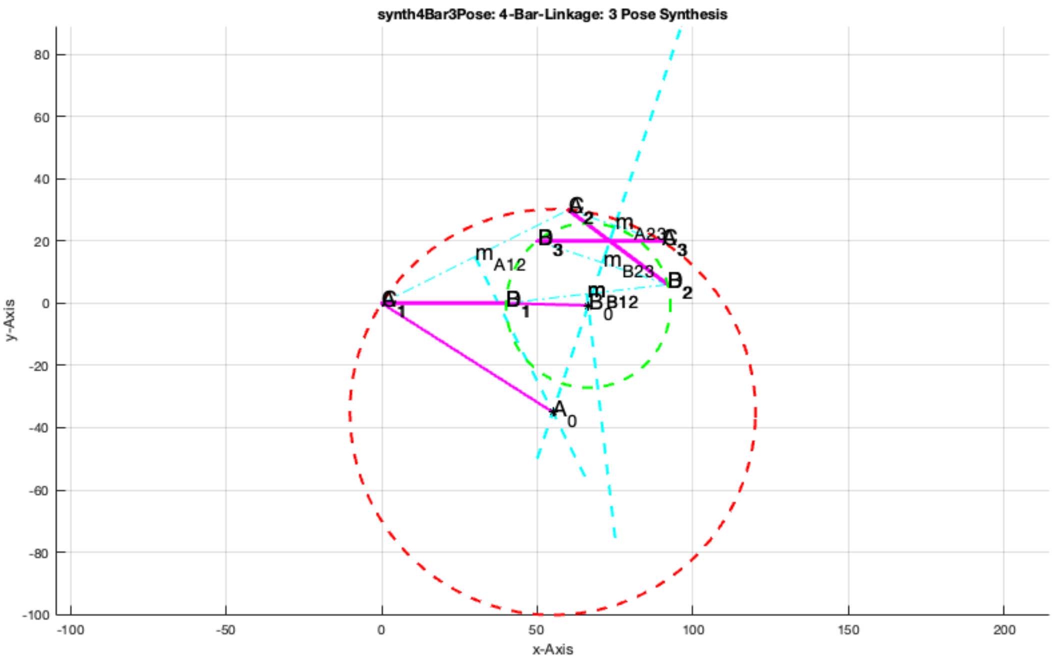


4. Find a General Solutions for the Three Pose Problem

As a solution, there are two straight lines on each of which the frame point A0 or the frame point B0 may be located. The intersection point of these two lines is the pole point P12. In a special case, both frame points are located at this point and a triangle is formed from the four-bar. In any case, the rack points can be displaced such that other secondary conditions can also be fulfilled.

```
l=500

imageFigureMovie('record');                          % Start Image Stack
synth4Bar3Pose(C1,D1,C2,D2,C3,D3,d);
% exp_2017_01_08(C1,D1,C2,D2,C3,D3,l,d);
imageFigureMovie(gcf);                               % RECORD ONE IMAGE
[~,FN2]=imageFigureMovie('write',smbFilename('synth4Bar3Pose.avi')); % SAVE IMAGE AS VIDEO
```

```
l =
   500
imageFigureSaveMovie: Writing figure movie with 1 frames in file: /Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/synth4Bar3Pose.avi.
```



5. Find a special Solution for the 4Bar-Linkage wit A0 and B0 on same level

If A0 and B0 are to lie on the same plane, B0+k*(P12-B0) must correspond to the Y coordinate of the Y coordinate of A0 in the y coordinate

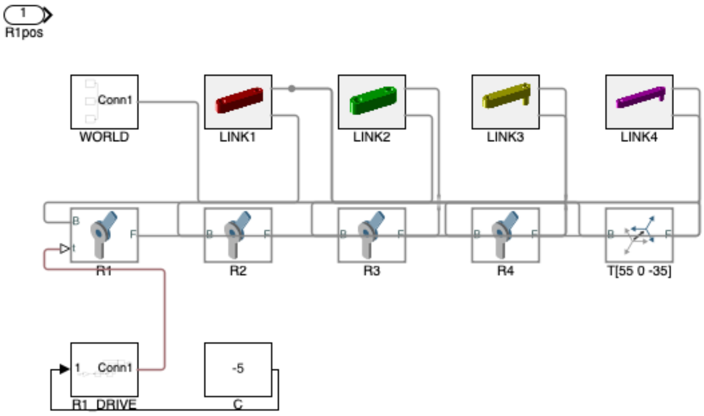
```
[A0,B0,A1,B1]=synth4Bar3Pose(C1,D1,C2,D2,C3,D3,d);
% [A0,B0,A1,B1]=exp_2017_01_08(C1,D1,C2,D2,C3,D3,l,d);
A0
B0

L1=norm(B0-A0)
L2=norm(B1-B0)
L3=norm(A1-B1)
L4=norm(A0-A1)

% L1=500; L2=400; L3=500; L4=400

L=[L1 L2 L3 L4]
LMax=find((L==max(L))); LMax=LMax(1);
LMin=find((L==min(L))); LMin=LMin(1);
l1=L(LMin)+L(LMax);
l2=sum(L)-l1;
l3=l1-l2
```

```
A0 =
   55.0000  -35.0000
B0 =
   66.4286   -0.7143
L1 =
   36.1403
L2 =
   26.4382
L3 =
    40
L4 =
   65.1920
L =
   36.1403   26.4382   40.0000   65.1920
l3 =
   15.4899
```

6. Create a SimMultiyBody System for the calculated solution

```
A=SGmodelLink(L1,'',1,2); A=SGmodelLink2(L1,0,1);
B=SGmodelLink(L2,'',1,2); B=SGmodelLink2(L2,0,1);
C=SGmodelLink(L3,'',1,2); C=SGmodelLink2(L3,0,-1);
D=SGmodelLink(L4,'',1,2); D=SGmodelLink2(L4,0,-1);

smbCreateSG (A,'LINK1','r');               % Add long rod as LINK1
smbCreateSG (B,'LINK2','g');               % Add short rod as LINK2
smbCreateSG (C,'LINK3','y');               % Add long rod as LINK3
smbCreateSG (D,'LINK4','m');               % Add short rod as LINK4
smbCreateJoint ('R','R1','LINK1.F','LINK2.B'); % Add a RR Joint
smbCreateJoint ('R','R2','LINK2.F','LINK3.B'); % Add a RR Joint
smbCreateJoint ('R','R3','LINK3.F','LINK4.B'); % Add a RR Joint
smbCreateJoint ('R','R4','LINK4.F','LINK1.B'); % Add a RR Joint
phi=atan2(B0(2)-A0(2),B0(1)-A0(1))
% phi=0;
smbCreateConnection('WORLD.ORIGIN','LINK1.B',TofR(rot(0,0,phi),[A0(1) 0 A0(2)])); % Connect Linkage to World Frame
smbCreateDrive ('R1');
smbSetJointInputTorque('R1');
smbCreateBlockConst('C','R1_DRIVE/1',-5)
ID=smbDrawNow;
smbSimulate(4);
```

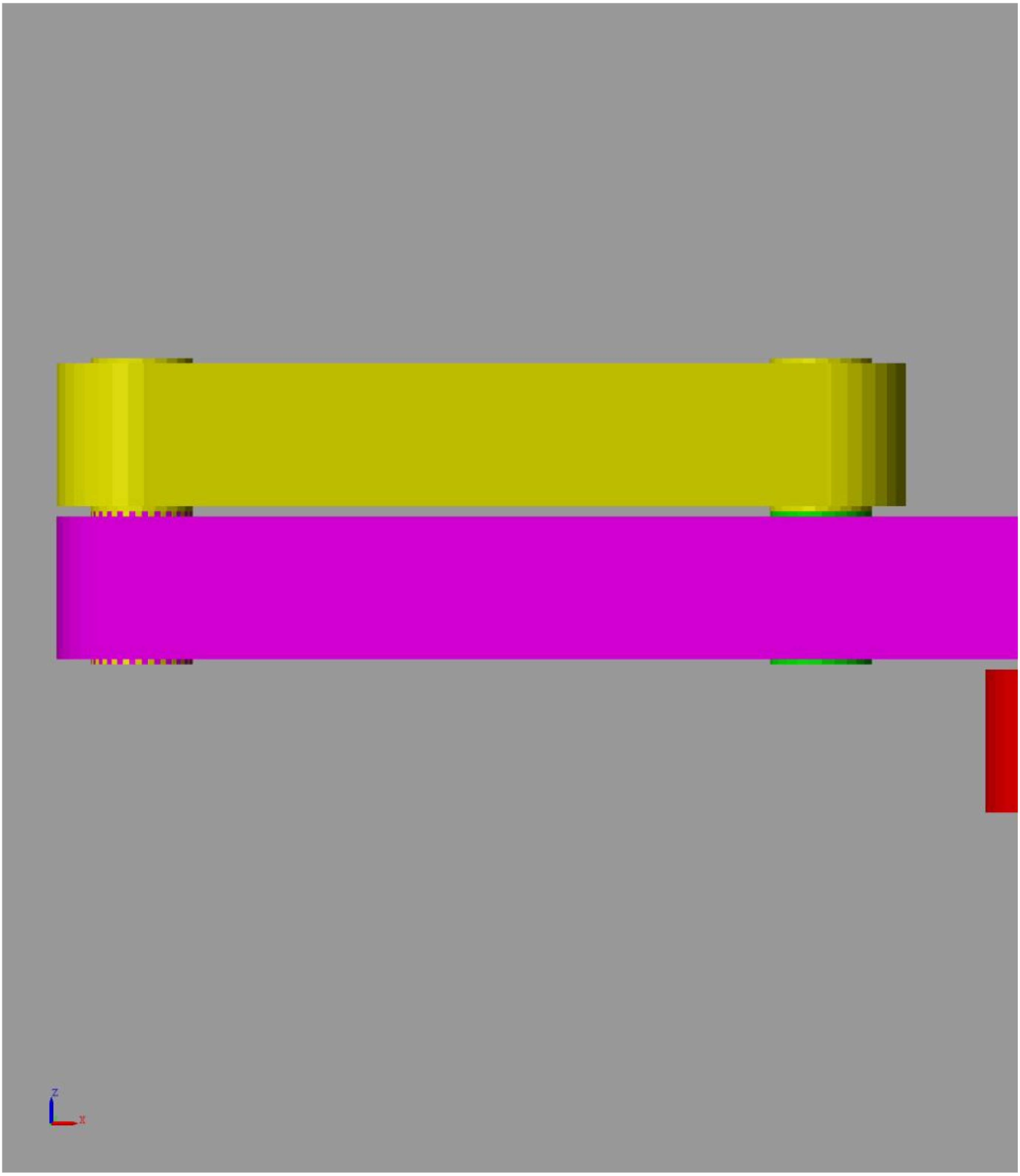
```
Warning: z(2) < z(1) ===>inverse faces
Warning: z(2) < z(1) ===>inverse faces
phi =
    1.2490
```



7. Show the Video of the Simulation

```
[I1,FN]=smbVideoSimulation (4);    % Simulate for 1 second
IT=imageVideoTitle(FN,{'SG-Lib Tutorial #27','3 Pose Syntheses','Tim C. Lueth','$date'},'',[0.44 0.74 1.14]);
IE=imageVideoEndtitle(FN);
% videoWriteClipMovie(smbFilename('3 Pose Syntheses SimMultiBody.avi'),IT,2,FN2,ID,1,FN,IE,1);
videoWriteClipMovie(smbFilename('3 Pose Syntheses SimMultiBody.avi'),IT,2,FN2,ID,1,FN,IE,1);
imshow(I1);
```

```
.........Creating a new video file (NO SOUND/2016b): '/Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/3 Pose Syntheses SimMultiBody.avi'
100% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50% 55% 60% 65% 70% 75% 80% 85% 90% 95% 100%
```

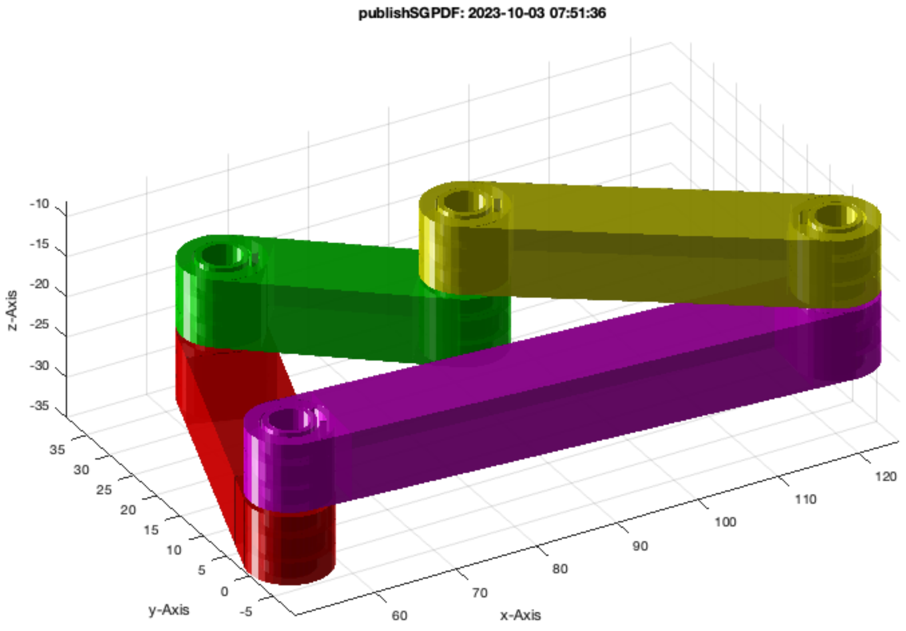


8. Now Create the Solid Geoemtry at time 0.78 seconds

```
SG=smbFullModelSimulation(0.74)
% SG=SGmagnifyVL(SG,'',[100 100 100]);
SGwriteSTL(SG,smbFilename('3-Pose-Synth'));
```

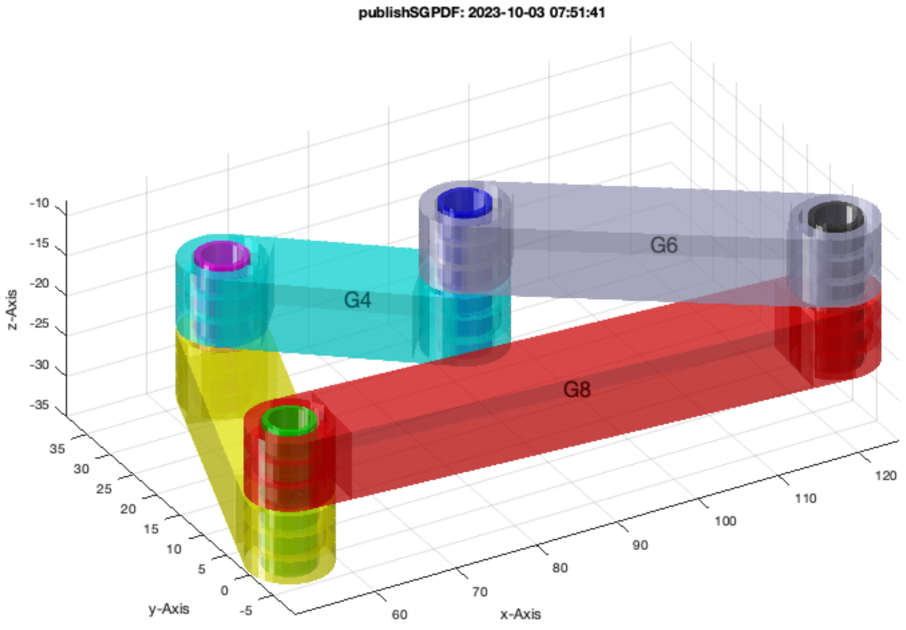
```
CREATING A FULL SOLID-MOVEMENT SIMULATION-MODEL 'SG_LIB_EXP_28' THAT RUNS At LEAST 0.74 SECONDS
===================================================================================================
Adding frame sensors for all solids of the model
```

```
Add frame sensors for 'LINK1.SG'
Add frame sensors for 'LINK2.SG'
Add frame sensors for 'LINK3.SG'
Add frame sensors for 'LINK4.SG'
===================================================================================================
simOut =
  Simulink.SimulationOutput:
                 simlog: [1x1 simscape.logging.Node]
                   sout: [1x1 Simulink.SimulationData.Dataset]
                   tout: [250x1 double]
                   xout: [1x1 Simulink.SimulationData.Dataset]

     SimulationMetadata: [1x1 Simulink.SimulationMetadata]
           ErrorMessage: [0x0 char]

LOADING BINARY STL-File: /Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/sbm_temp_LINK1.stl
Binary Header: COLOR=RGBA,MATERIAL=AAAABBBBCCCCDDDD;SOLID "/Users/timlueth/Desktop/tmp_SG_LIB_E
Color of solid defined as: "k"
Alpha of solid defined as: 65.00
Number of facets: 2494
Number of vertices: 1258
SGN2SGT: 2 Frames ('B', 'F') decoded in STL format.

LOADING BINARY STL-File: /Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/sbm_temp_LINK2.stl
Binary Header: COLOR=RGBA,MATERIAL=AAAABBBBCCCCDDDD;SOLID "/Users/timlueth/Desktop/tmp_SG_LIB_E
Color of solid defined as: "k"
Alpha of solid defined as: 65.00
Number of facets: 2494
Number of vertices: 1258
SGN2SGT: 2 Frames ('B', 'F') decoded in STL format.

LOADING BINARY STL-File: /Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/sbm_temp_LINK3.stl
Binary Header: COLOR=RGBA,MATERIAL=AAAABBBBCCCCDDDD;SOLID "/Users/timlueth/Desktop/tmp_SG_LIB_E
Color of solid defined as: "k"
Alpha of solid defined as: 65.00
Number of facets: 2678
Number of vertices: 1350
SGN2SGT: 2 Frames ('B', 'F') decoded in STL format.

LOADING BINARY STL-File: /Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/sbm_temp_LINK4.stl
Binary Header: COLOR=RGBA,MATERIAL=AAAABBBBCCCCDDDD;SOLID "/Users/timlueth/Desktop/tmp_SG_LIB_E
Color of solid defined as: "k"
Alpha of solid defined as: 65.00
Number of facets: 2678
Number of vertices: 1350
SGN2SGT: 2 Frames ('B', 'F') decoded in STL format.


CREATED A SOLID GEOMETRY OF THE FULL SIMULATION-MODEL 'SG_LIB_EXP_28' AT TIME: 0.74 SECONDS
===================================================================================================
SG =
  4×1 cell array
    {1×1 struct}
    {1×1 struct}
    {1×1 struct}
    {1×1 struct}
publishSGPDF:<a href = "matlab: openbydoubleclick ('/Users/timlueth/Desktop/tmp_SG_LIB_EXP_28')">/Users/timlueth/Desktop/tmp_SG_LIB_EXP_28/</a><a href
```



```
SGfigure; view(-30,30); SGplot(SG,'m');  SGanalyzeGroupParts(SG);
```

```
4% 8% 12% 16% 20% 24% 28% 32% 36% 40% 44% 48% 52% 56% 60% 64% 68% 72% 76% 80% 84% 88% 92% 96% 100%
SGanalyzeGroupParts: 8 separated parts found
```



Final Remarks

```
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 07:51:42!
Executed 03-Oct-2023 07:51:44 by 'timlueth' on a MACI64 using Mac OSX 13.6 | R2023a Update 5 | SG-Lib 5.4
======================================= Used Matlab products: =====================================
distrib_computing_toolbox
```

```
fixed_point_toolbox
map_toolbox
matlab
simmechanics
simscape
simulink
=====================================================================================================
```

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