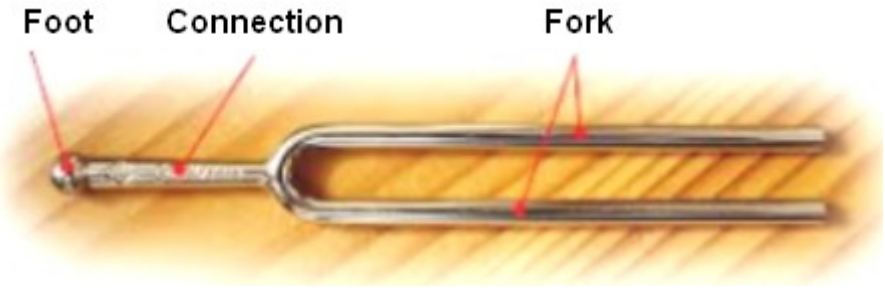
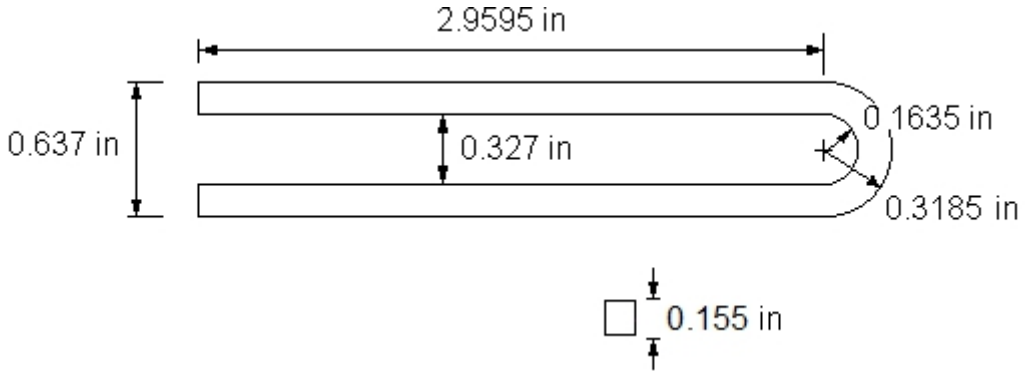
Part 5: Dynamic Analysis with FEM-System MEANS V11

This is a FEM calculation with FEM-System MEANS V10 of a 440 Hz Tuning Fork with which you can adjust the musical instruments according to the reference tone or it are also used in the medicine for hearing tests.



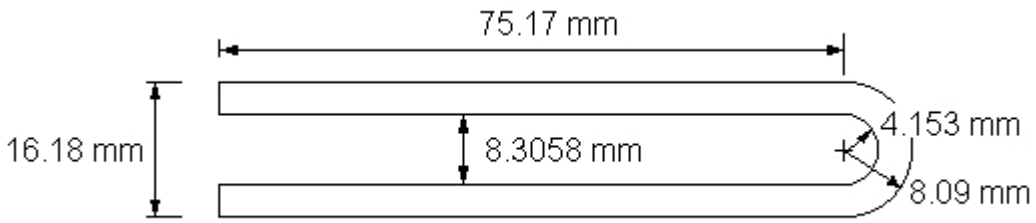
The dimensions and material data must first be converted to metric units by USA measurement units. The tuning fork model is produced in MEANS V10 without foot and connection as follows:

US Measurement:



E-Modulus = 29 msi = 29 000 psi
Poisson ratio = 0.29
Density = 0.283 lb/in³
Thickness = 0.155 in

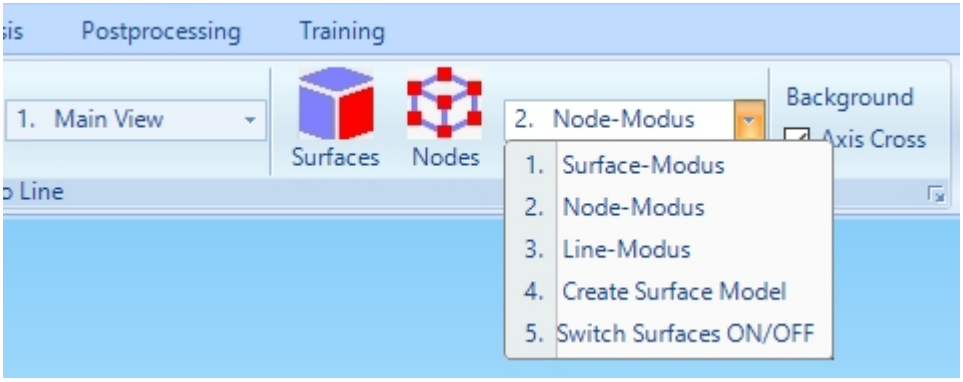
Metric Measurement:



E-Modulus = 200 000 N/mm²
Poisson ratio = 0.29
Density = 7850 kg/m³
Thickness = 3.937 mm

Create Arcs

Start the program "MEANS V12 for DirectX11" using the desktop icon  ,
select the „View“ tab and menu „3. Line-Modus“ to switch to the Line Modus.

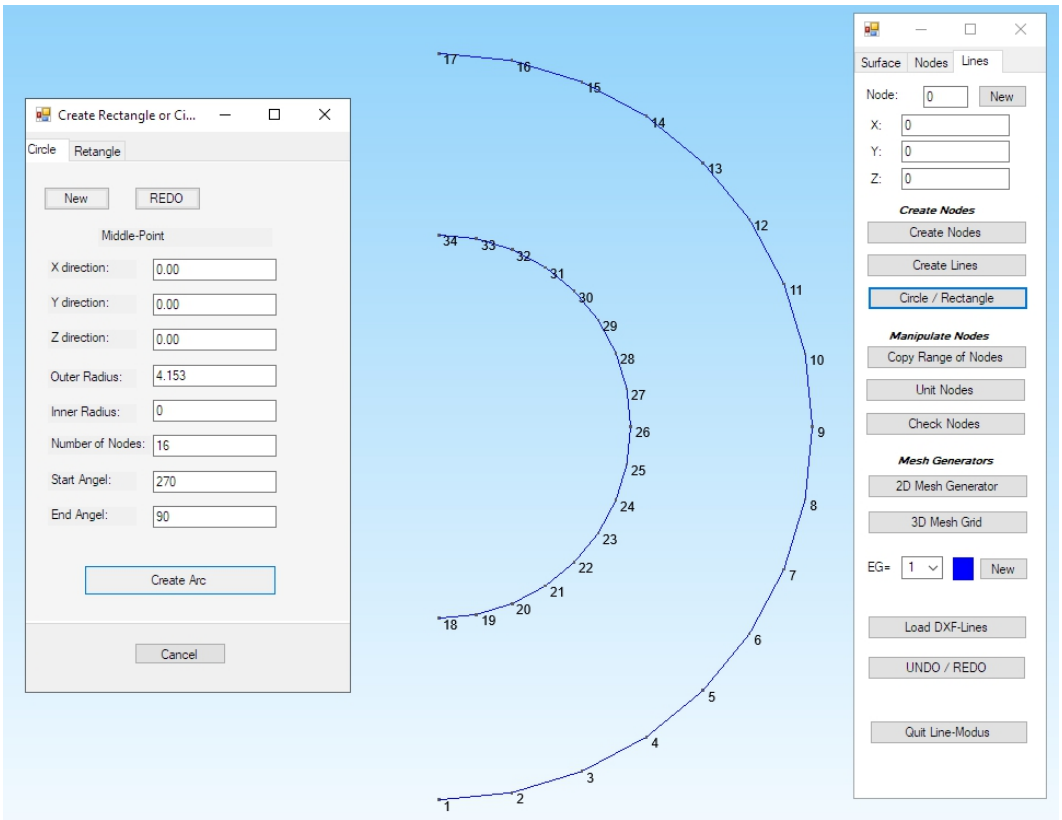


A new menu will appear on the right, select menu "Create Arcs" to create two arcs:

Circular Arc 1:
Center: xm = 0, ym = 0, zm = 0
Radius = 8.09
Number of Nodes = 16
Start Angle = 270
End Angle = 90

Circular Arc 2:
Center: xm = 0, ym = 0, zm = 0
Radius = 4,153
Number of Nodes = 16
Start Angle = 270
End Angle = 90

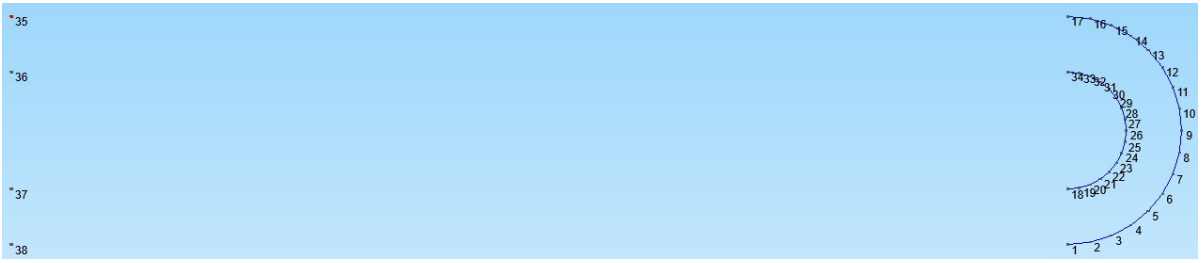
Also, in Node Modus, switch on the node numbering to see the 34 nodes better:



Enter 4 single nodes

In line mode, enter the 4 single nodes of the left side one by one with "New" and "Create Nodes":

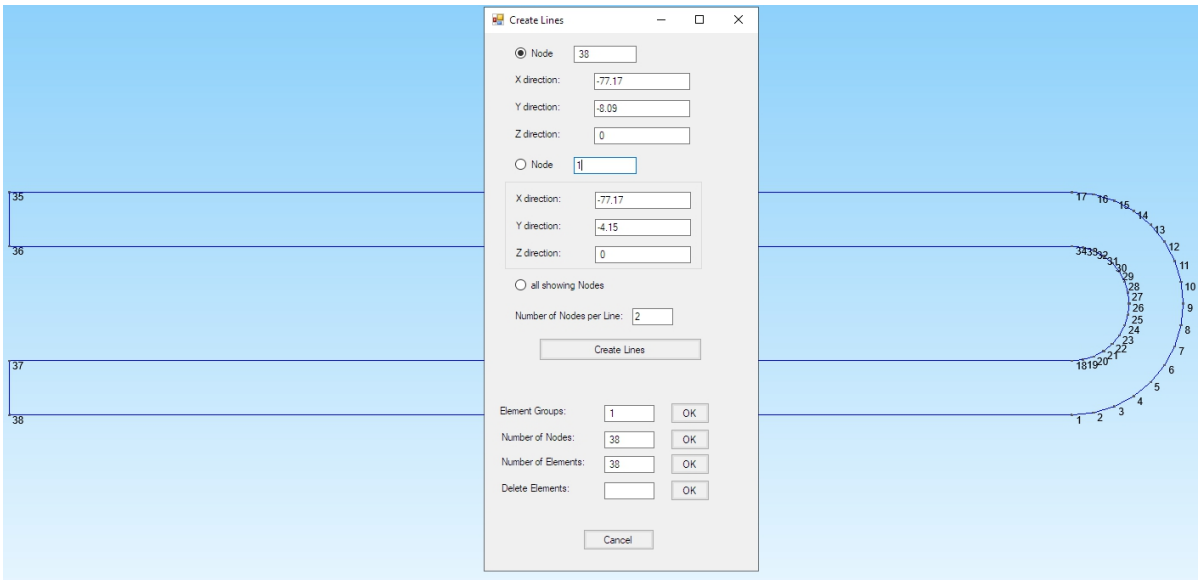
Node 35 = X = -75.17 Y = 8.09
Node 36 = X = -75.17 Y = 4.15
Node 37 = X = -75.17 Y = - 4.15
Node 38 = X = -75.17 Y = - 8.09



Create Lines

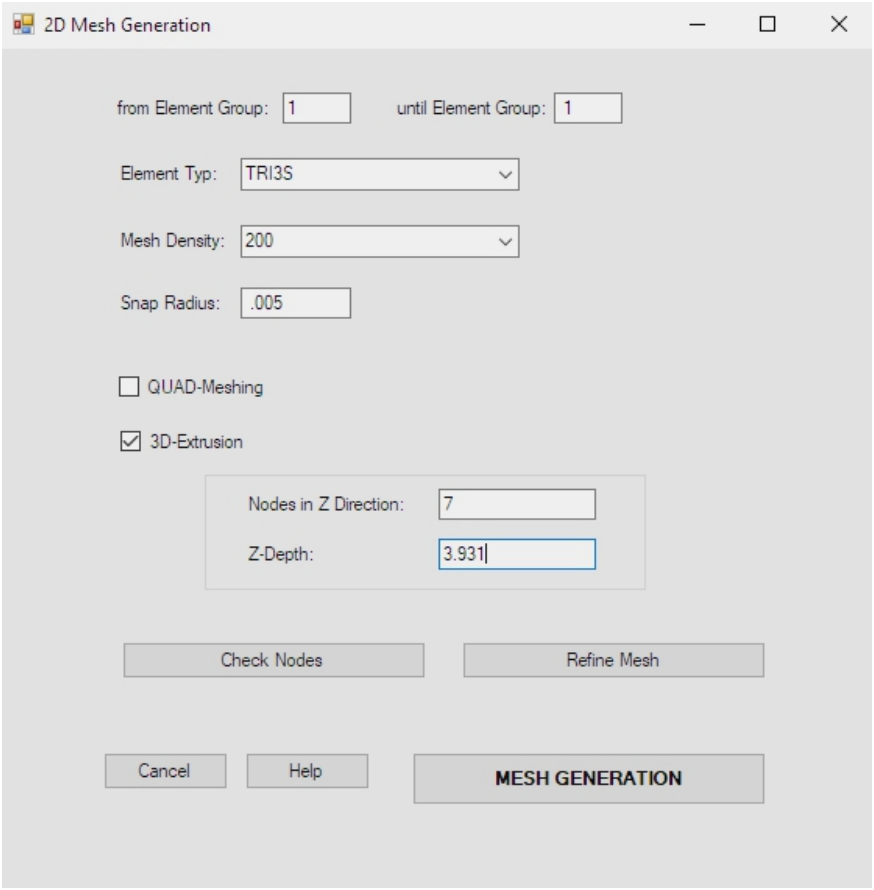
In Lines Modus select menu "Create Lines" menu and create the lines by first clicking on the first node, then clicking on the end node, and selecting "Create Lines“ and creating the following 6 lines:

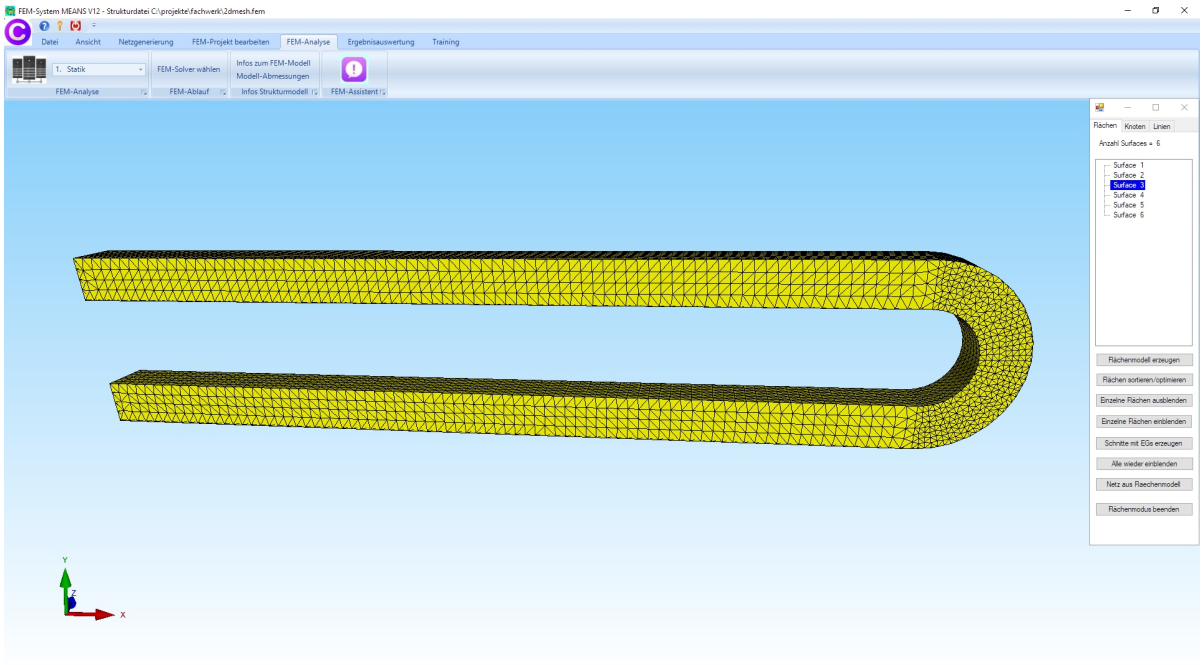
Line 17-35, line 35-36, line 36-34, and line 18-37, line 37-38, line 38-1



2D Mesh Generator with Extrusion

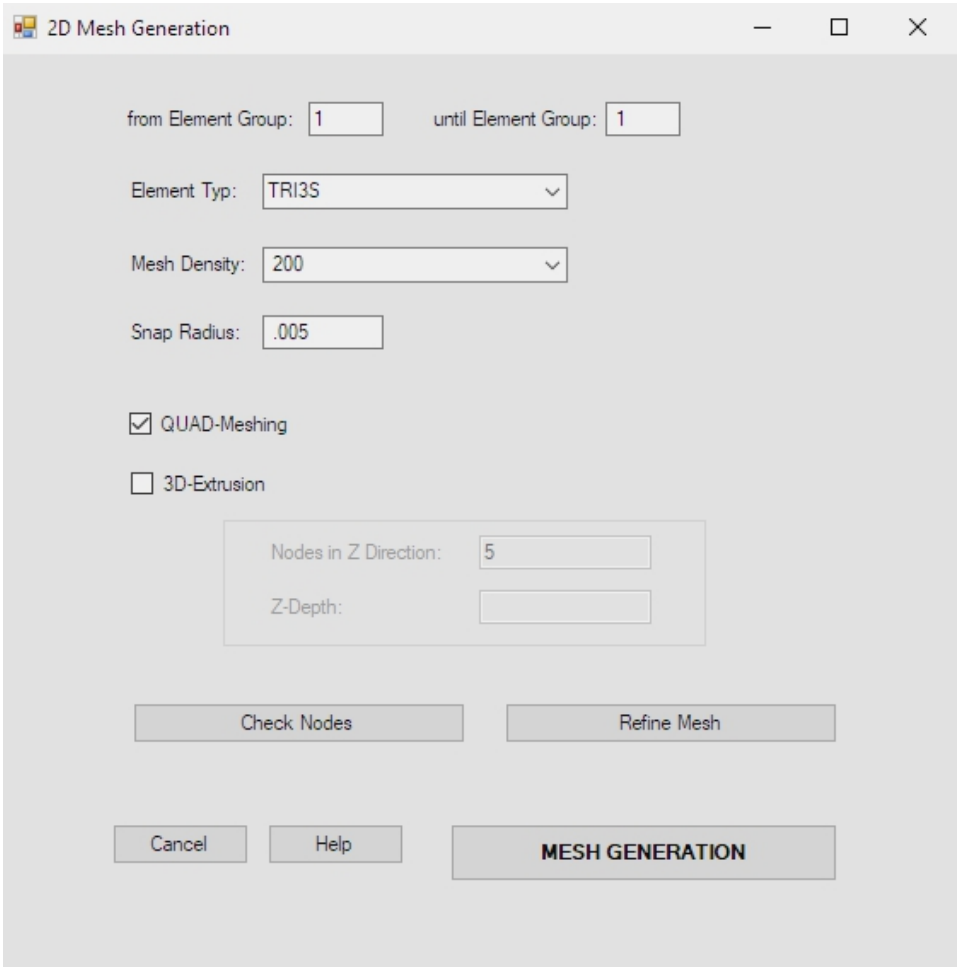
In Line Mode, select “2D Mesh Generator” with a Mesh Density of “200” and “3D-Extrusion“ with Nodes in Z Direction of “7” and a Z-Depth of "3,931"
to first generate a triangular mesh and then to extrude a 3D model consisting of 11616 pentahedral elements and 8211 nodes.



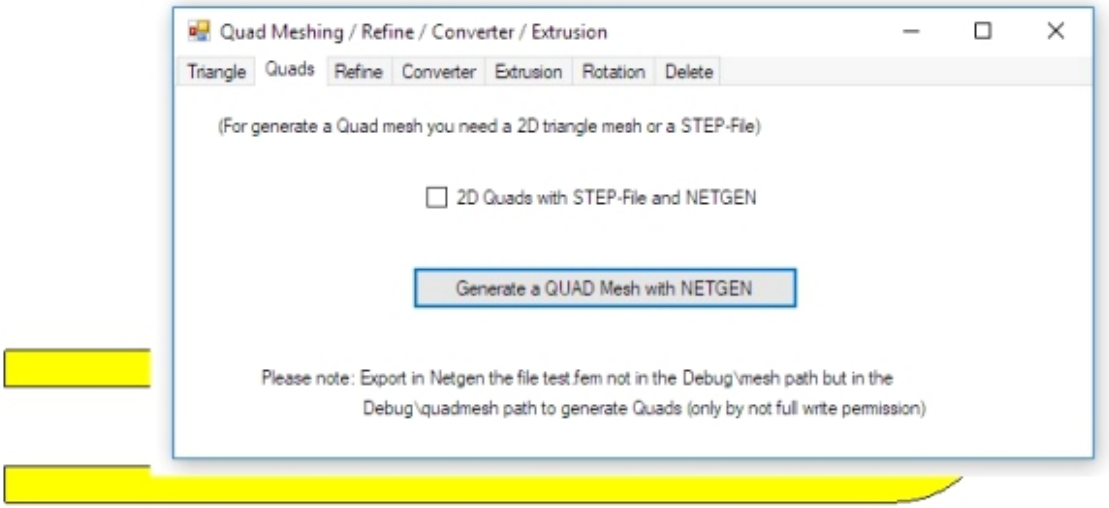


QUAD Meshing

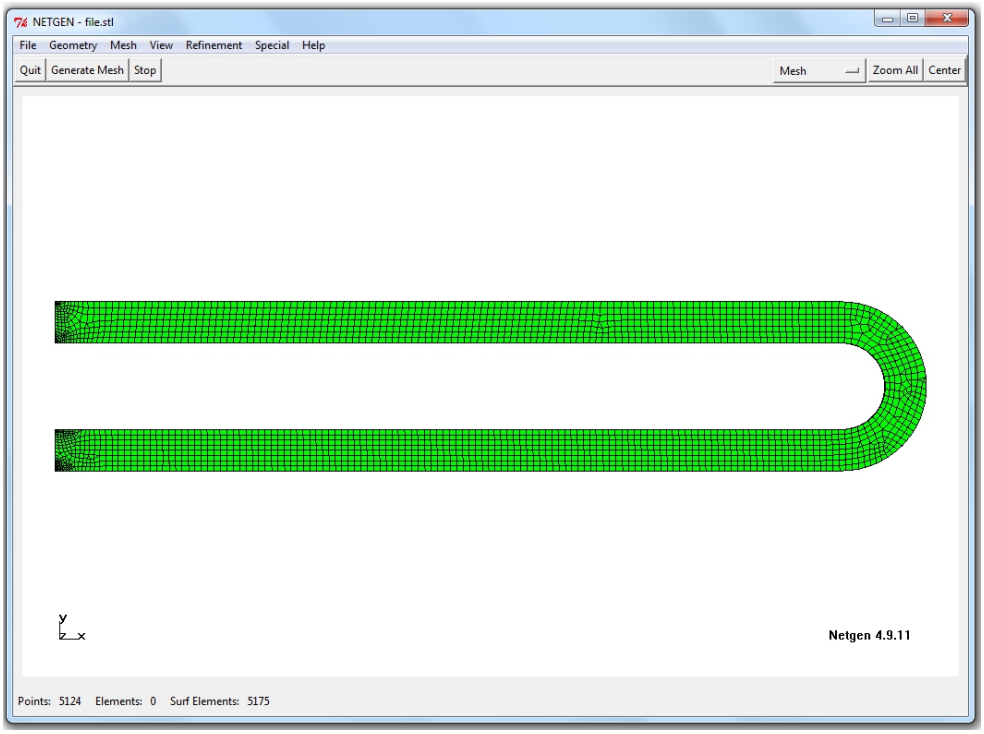
Select "2D Mesh Generator" again and select "QUAD-Meshing“ to generate a triangular mesh for using it as a template in NETGEN.



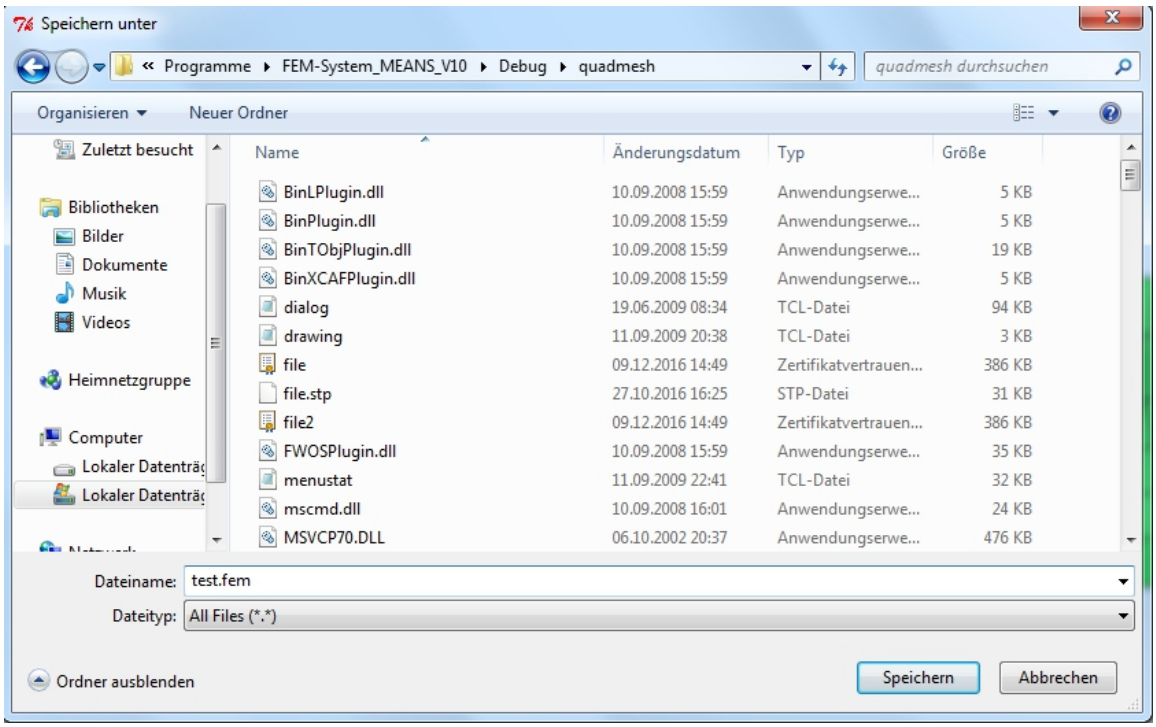
The generated triangular mesh is now displayed as a converted STL model in NETGEN.



Select „Generate Mesh“ with the mesh density “very fine” and generate a QUAD mesh with 5124 nodes and 5157 QUA4S elements.



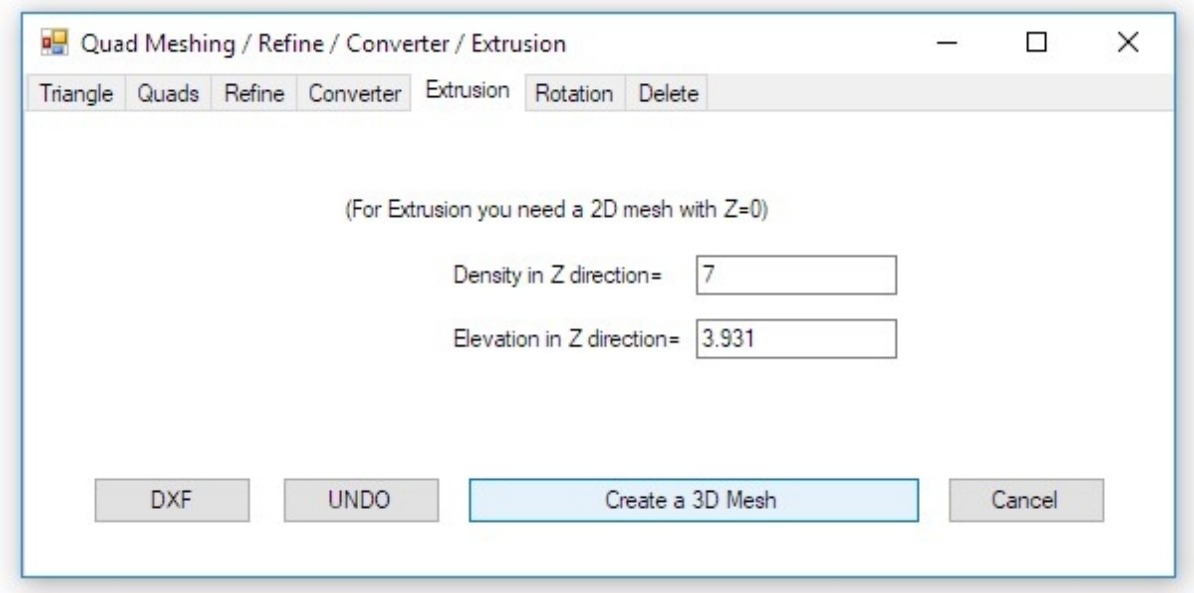
Use menu "File" and "Export Mesh" to export the FEM mesh under the name "test.fem" to the default debug quadmesh directory so that it can be automatically converted and imported into MEANS V12.



After the model check, a QUAD mesh with 6201 nodes is created.

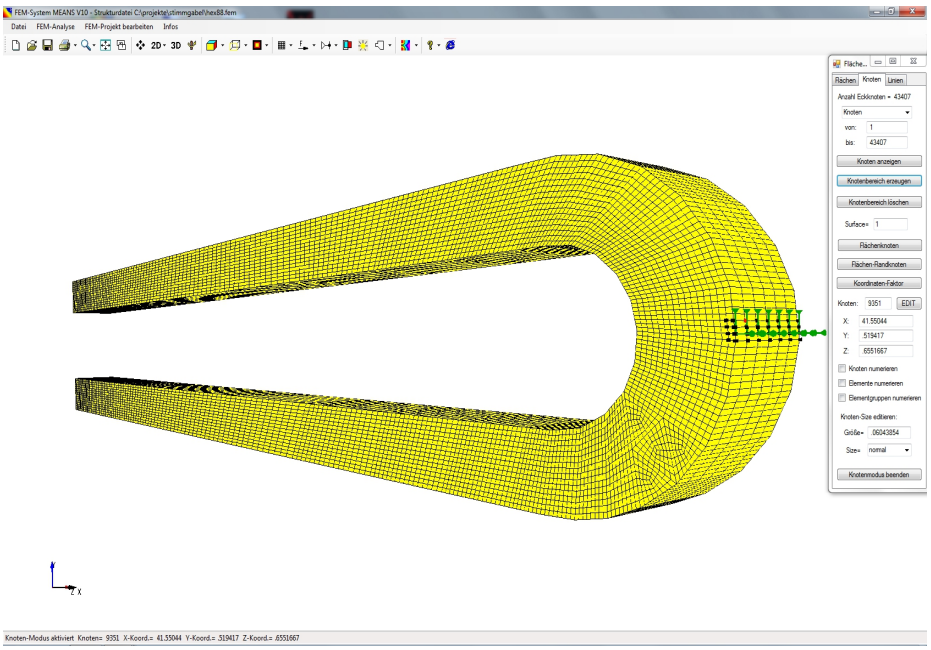
Hexahedral model

Select menu "QUAD-Meshes, Refine, Delete...“ again and the register "Extrusion" to generate a Hexaeder mesh with 39944 HEX8 elements and 43407 nodes. Use the following setting:



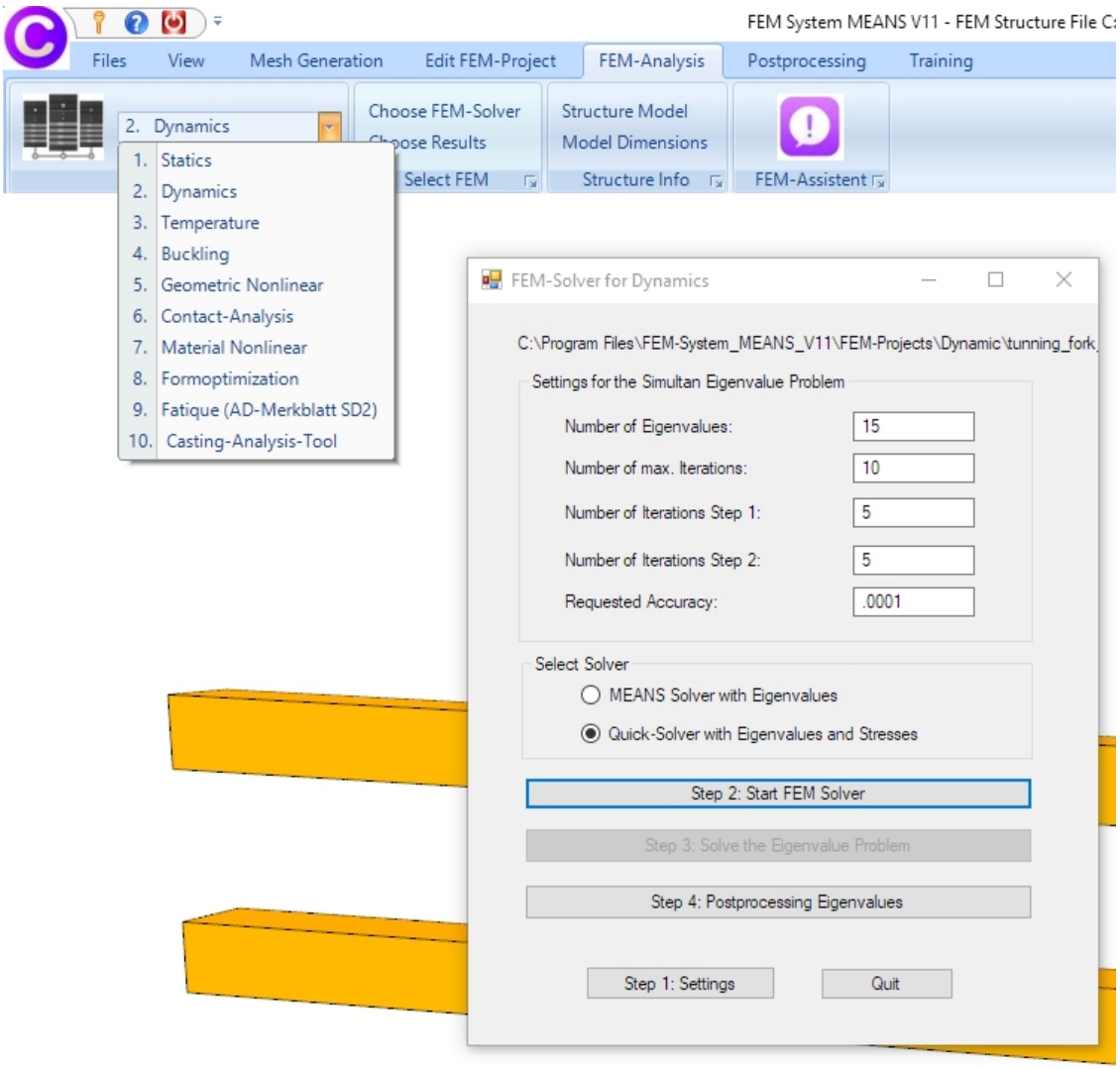
Create Boundary Conditions

Create a Range of Nodes in Node Modus and choose „Edit FEM-Project“ tab and menu „Boundary Conditions" and clamped fixed the Range of Nodes with the Selection „All displayed nodes“ in the X, Y and Z direction.

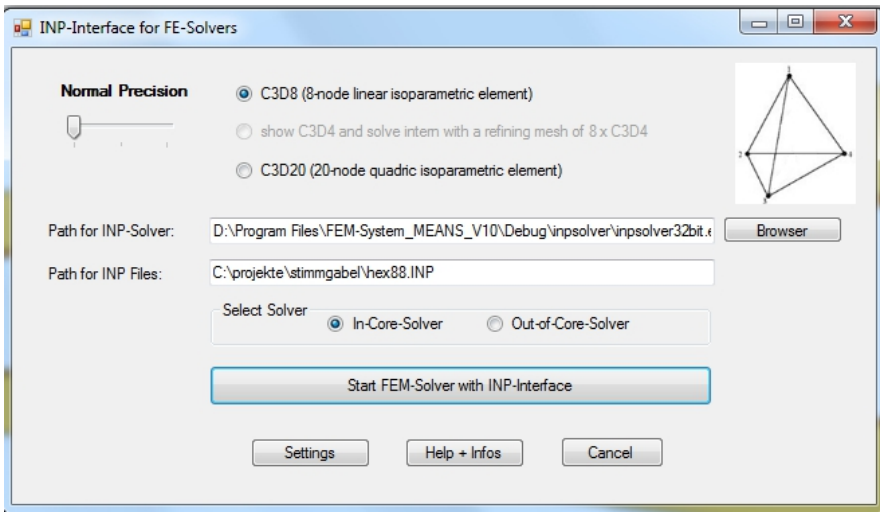


Dynamic Analysis

Select the „FEM Analysis" tab and "2. Dynamics" and calculate the lowest 15 eigenfrequencies with the Quick Solver with the following setting.



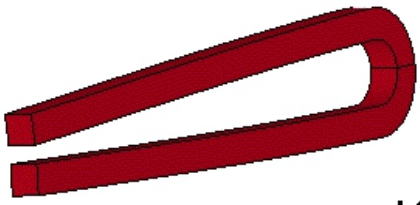
Calculate the eigenvalue with the quick quick solver:



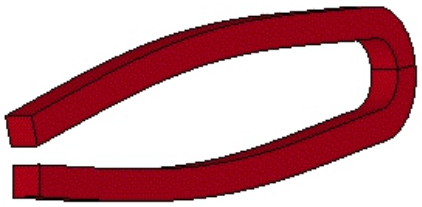
Results comparison

The eigenfrequencies calculated with different meshes and element types are compared with the eigenfrequencies of the FEM system LS-DYNA. The result comparison shows good agreement with almost all element types. The greatest deviations occur with the linear tetrahedral element TET4. But if the same TET4 mesh is calculated with the TET4X8 developed by HTA software, the results will improve over 30%

Eigenfrequenz Nr. 1 = 450 Hz

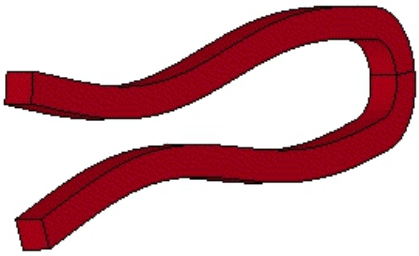


Eigenfrequenz Nr. 2 = 2823 Hz

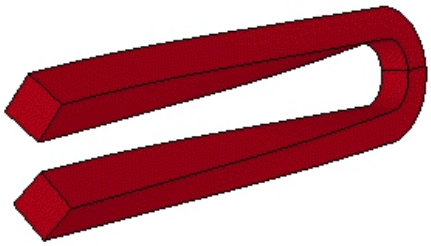


LS-DYNA

Eigenfrquenz Nr. 3 = 7460 Hz

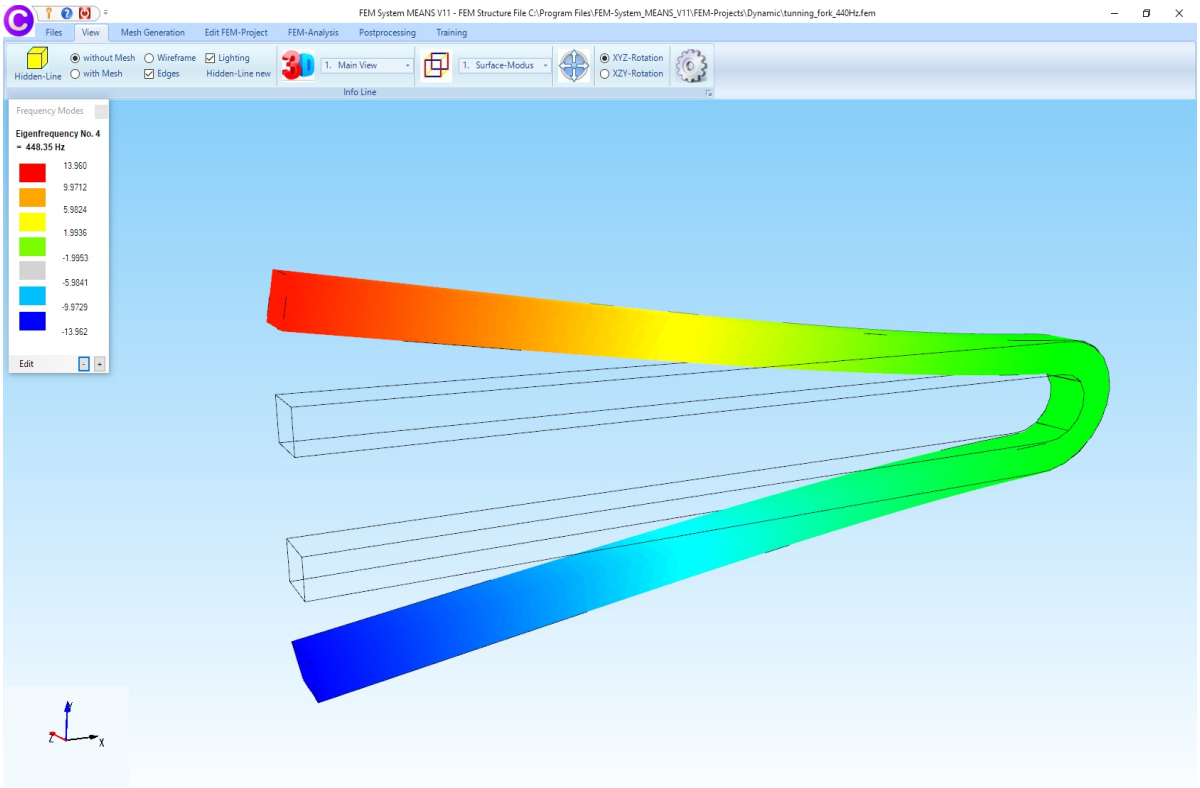


Eigenfrequenz Nr. 4 = 8438 Hz

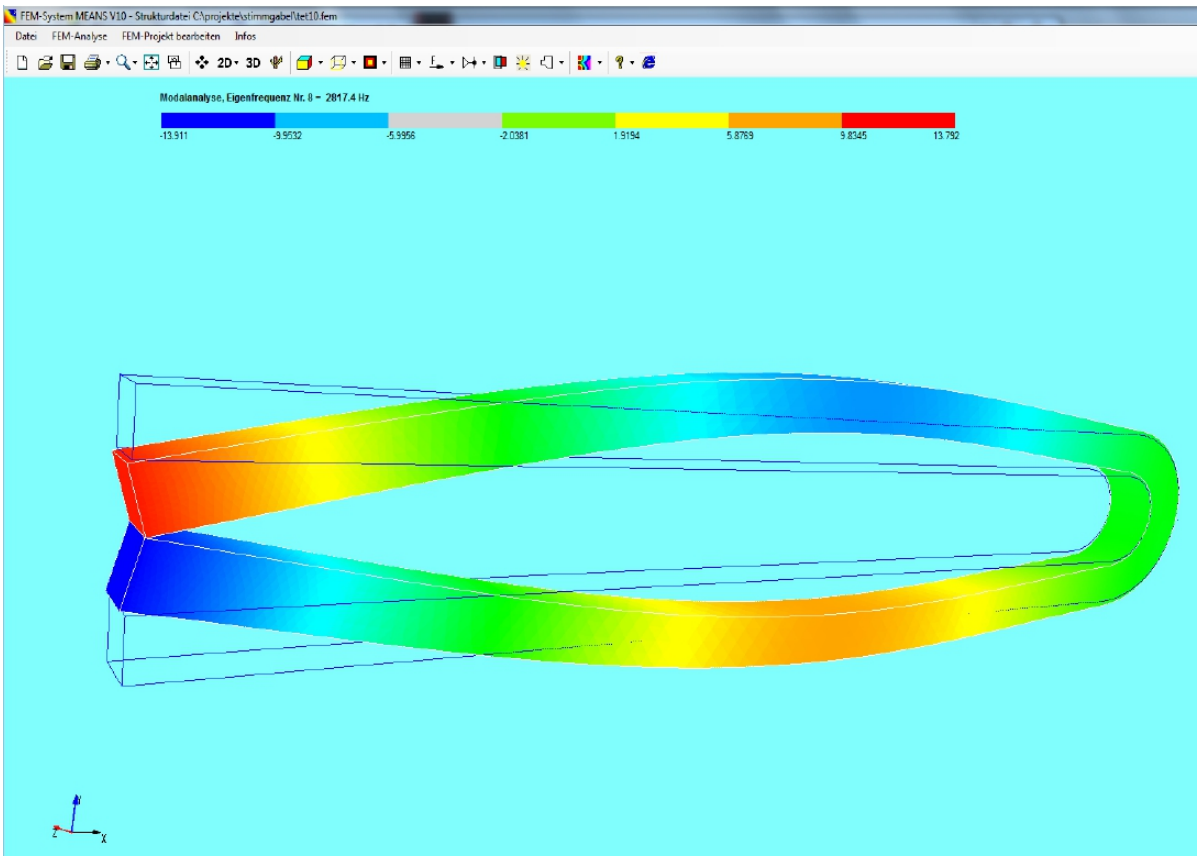


Elementtyp	Knoten	Elemente	1. Biegesch.	2. Biegesch.	3. Biegesch.	Torsionssch.
LS-DYNA	?	?	450 HZ	2 823 Hz	7 460 Hz	8 438 Hz
Dreieck	18 379	8 764	452 Hz	2 843 Hz	7 539 Hz	-
Viereck	7 366	2 081	453 Hz	2 846 Hz	7 456 Hz	-
TET4	18 539	87 744	471 Hz	3 072 Hz	8 149 Hz	9 659 Hz
TET4X8	132 085	701 952	456 Hz	2 897 Hz	7 594 Hz	8 800 Hz
TET10	132 085	87 744	449 Hz	2 817 Hz	7 401 Hz	8 413 Hz
HEX8	43 407	34 944	450 Hz	2 839 Hz	7 422 Hz	8 400 Hz
HEX20	164 781	39 944	449 Hz	2 816 Hz	7 346 Hz	8 322 Hz
PEN6	59 150	94 596	451 Hz	2 839 Hz	7 446 Hz	8 444 Hz
PEN15	278 301	94 596	449 Hz	2 818 Hz	7 340 Hz	8 315 Hz

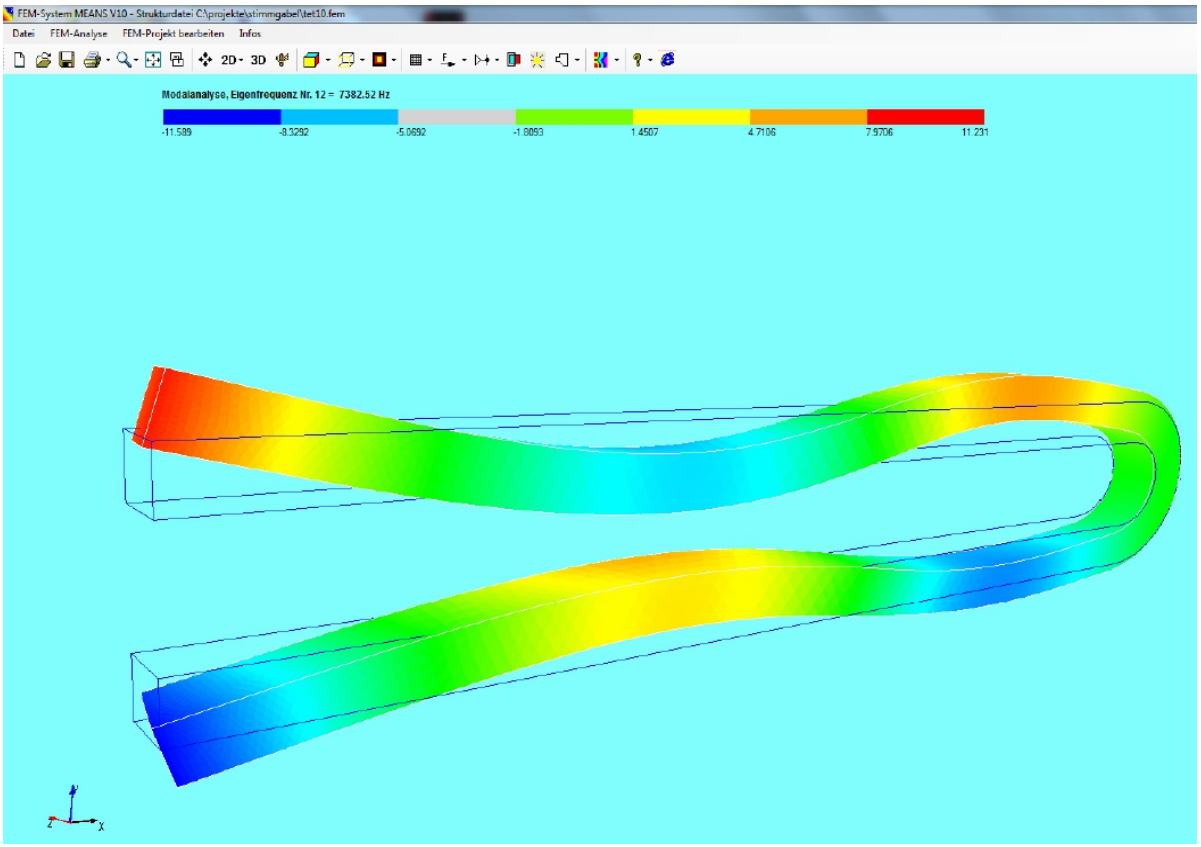
Eigenfrequency No. 4 = 449 Hz (first bending Eigenfrequency)



Eigenfrequency No. 8 = 2817 Hz (second bending Eigenfrequency)



Eigenfrequency No. 12 = 7382 Hz (third bending Eigenfrequency)



Eigenfrequency No. 13 = 8398 Hz (first torsion Eigenfrequency)