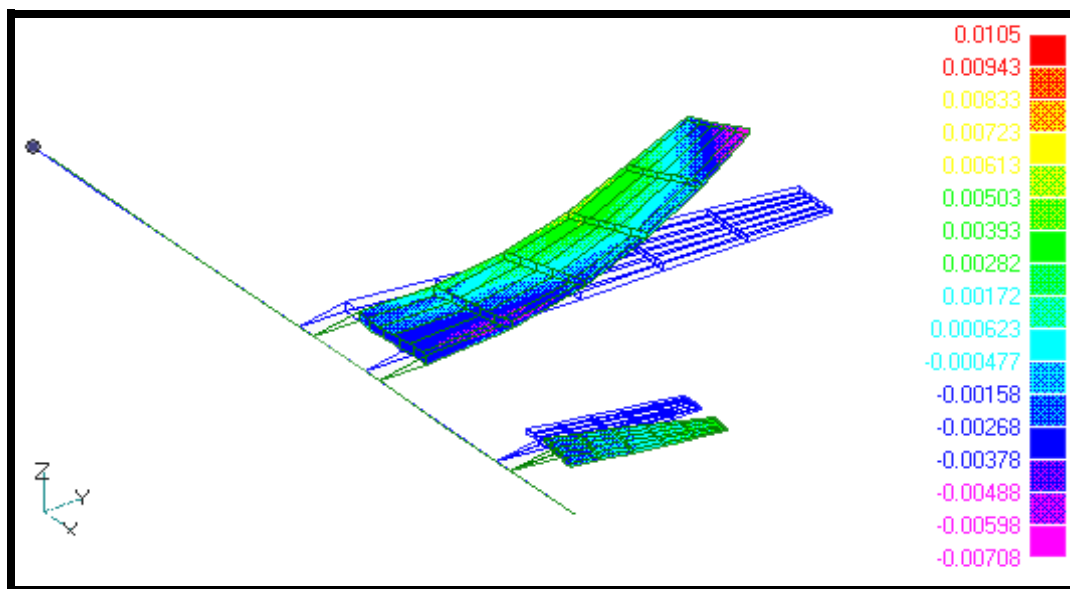


## WORKSHOP 11

# *Modal Analysis of a Half Aircraft Model Using Symmetry*



### Objectives:

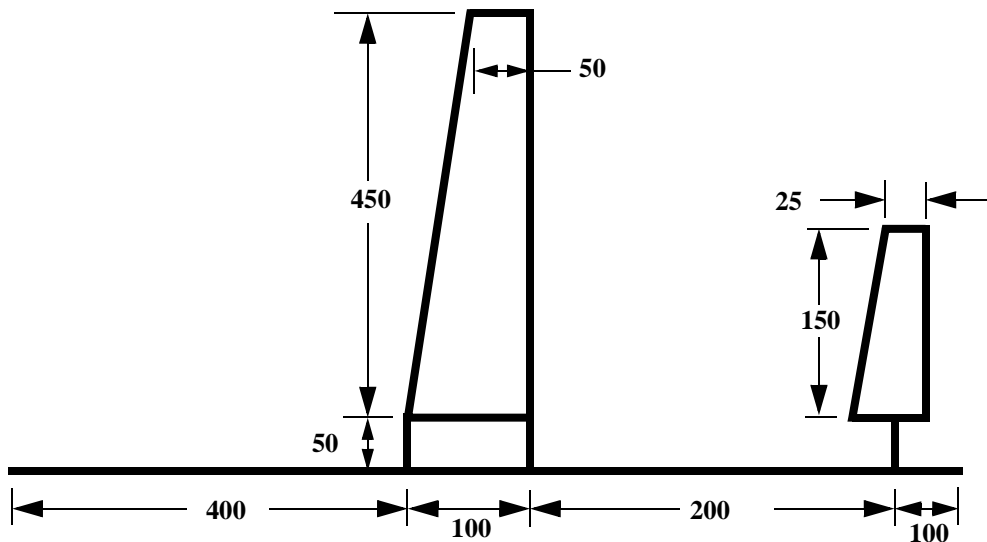
- Create a geometric representation of half an aircraft.
- Use the geometry model to define an analysis model comprised of bars and membranes.
- Create symmetric and antisymmetric boundary conditions.
- Submit the file for analysis in MSC.Nastran for Windows.
- Find the first five flexible modes of the airframe for each boundary condition.



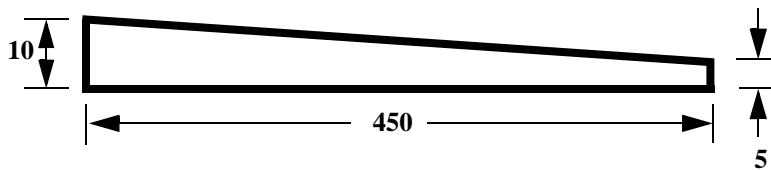
### Model Description:

For this example, use the concept of symmetry to find the modes of a full aircraft using a half aircraft model and two boundary conditions. The model will consist of a row of BARS for the fuselage and a mesh of membrane elements for the wing and tail.

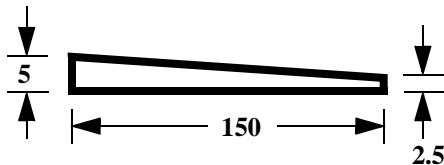
Description: Aircraft Dimensions



Wing: Side View



Tail: Side View



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**Table 1.1 - Material Properties of the aircraft components**

Fuselage, Area	7.85 in <sup>2</sup>
Fuselage, Moment of Inertia, I1	9818 in <sup>4</sup>
Fuselage, I2	9818 in <sup>4</sup>
Torsional Constant, J	19635 in <sup>4</sup>
Wing Skin Thickness	0.050 in
Wing Rib Thickness	0.005 in
Tail Skin Thickness	0.010 in
Tail Rib Thickness	0.005 in
Mass/Weight Factor	2.59E-3 sec <sup>2</sup> /in
Young's Modulus	10.0E6 lbs/in <sup>2</sup>
Shear Modulus	3.7E6 lbs/in <sup>2</sup>
Weight Density	0.1 lbs/in <sup>3</sup>

Note: Fuselage Properties are 1/2 of a thin ring with r = 50 and t = 0.05

## Exercise Procedure:

1. Start up MSC.Nastran for Windows 4.0 and begin to create a new model.

Double click on the icon labeled **MSC.Nastran for Windows V4.0**.

On the *Open Model File* form, select **New Model**.

*Open Model File:*

**New Model**

2. Create a material called **mat\_1**.

### Model/Material...

*Title:*

**mat\_1**

*Youngs Modulus:*

**10E6**

*Shear Modulus:*

**3.7E6**

*Mass Density:*

**0.1**

**OK**

**Cancel**

3. Create properties.

From the pulldown menu, select **Model/Property**.

### Model/Property...

*Title:*

**wing\_skin**

*Thickness, Tavg or T1:*

**0.050**

To select the material, click on the list icon next to the databox and select **mat\_1**.

*Material:*

**1.. mat\_1**

### Elem/Property Type...

*Plane Elements:*

**Membrane**

**OK**

**OK**

*Title:*

**tail\_skin**

*Thickness, Tavg or T1:*

**0.01**

**OK**

*Title:*

**rib**

*Thickness, Tavg or T1:*

**0.005**

**OK**

*Title:*

**fuselage**

**Elem/Property Type...**

*Line Elements:*

**Bar**

**OK**

*Area, A:*

**7.85**

*Moment of Inertia, I1 or Izz:*

**9818**

*I2 or Iyy:*

**9818**

*Torsional Constant, J:*

**19635**

**OK**

**Cancel**

4. Begin creating the geometry of the half aircraft.

**Geometry/Curve - Line/Continuous...**

X: **0**

Y: **0**

Z: **0**

**OK**

X: **400**

Y: **0**

Z: **0**

**OK**

X: **500**

Y: **0**

Z: **0**

**OK**

X: **700**

Y: **0**

Z: **0**

**OK**

X: **800**

Y: **0**

Z: **0**

**OK**

**Cancel**

It will ask you, OK to close continuous line?

**No**

Turn the workplane off.

**View/Workplane... <F2>**

**Draw Workplane**

**Done**

Adjust the view using the **Autoscale** and **Rotate** command.

**View/Autoscale <Ctrl+A>**

**View/Rotate... <F8>**

**Dimetric**

**OK**

Create surfaces to represent the wing and tail skin.

**Geometry/Surface/Corners...**

*Wing Lower Surface:*

X:	<b>400</b>	Y:	<b>50</b>	Z:	<b>0</b>	<b>OK</b>
X:	<b>500</b>	Y:	<b>50</b>	Z:	<b>0</b>	<b>OK</b>
X:	<b>500</b>	Y:	<b>500</b>	Z:	<b>0</b>	<b>OK</b>
X:	<b>450</b>	Y:	<b>500</b>	Z:	<b>0</b>	<b>OK</b>

*Wing Upper Surface:*

X:	<b>400</b>	Y:	<b>50</b>	Z:	<b>10</b>	<b>OK</b>
X:	<b>500</b>	Y:	<b>50</b>	Z:	<b>10</b>	<b>OK</b>
X:	<b>500</b>	Y:	<b>500</b>	Z:	<b>5</b>	<b>OK</b>
X:	<b>450</b>	Y:	<b>500</b>	Z:	<b>5</b>	<b>OK</b>

*Tail Lower Surface:*

X:	675	Y:	50	Z:	0	OK
X:	725	Y:	50	Z:	0	OK
X:	725	Y:	200	Z:	0	OK
X:	700	Y:	200	Z:	0	OK

*Tail Upper Surface:*

X:	675	Y:	50	Z:	5	OK
X:	725	Y:	50	Z:	5	OK
X:	725	Y:	200	Z:	2.5	OK
X:	700	Y:	200	Z:	2.5	OK

Cancel

Magnify the model to get a better view.

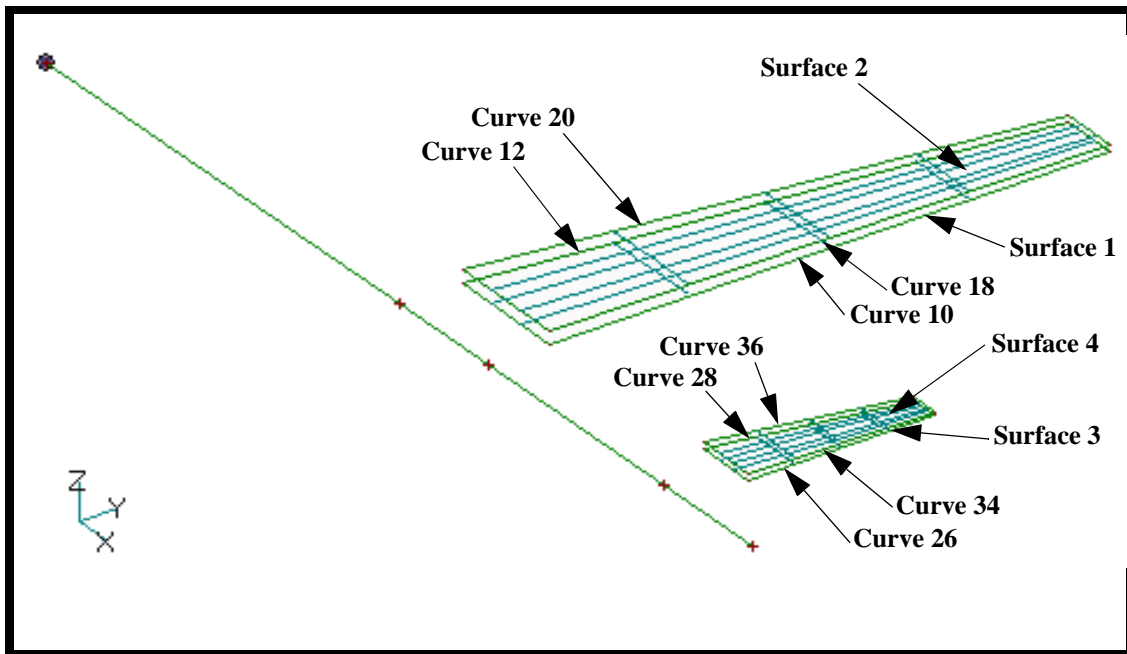
**View/Magnify... <Ctrl+M>**

Fill View

OK

Your display should look like the following.

**Figure 11.1 - Half Aircraft Geometry**



Create surfaces to represent the spar webs.

Turn on the curve IDs.

**View/Options... <F6>**

*Options:* **Curve**

*Label/Mode:* **ID**

**OK**

**Geometry/Surface/Ruled...**

*From Curve:*  *To Curve:*

*From Curve:*  *To Curve:*

*From Curve:*  *To Curve:*

*From Curve:*  *To Curve:*

**Cancel**

5. Mesh the fuselage.

**Mesh/Mesh Control/Size Along Curve...**

*<select fuselage curves - ID # 1, 2, 3, 4>*

**OK**

**Number of Elements**

**Element Size**

**OK**

**Cancel**

**Mesh/Geometry/Curve...**

**Previous**

---

This will select the 4 fuselage curves.

*Property:*

*Base X:*  *Y:*  *Z:*

*Tip X:*  *Y:*  *Z:*

Turn off the curve IDs.

**View/Options... <F6>**

*Options:*

*Label/Mode:*

6. Create mesh seeds and mesh on the wing, tail, and spar surfaces.

**Mesh/Mesh Control/Mapped Divisions on Surface...**

*<select the four top and bottom surfaces - ID # 1, 2, 3, 4>*

*Number of Elements s:*  *t:*

*<select the four spar surfaces - ID # 5, 6, 7, 8>*

*Number of Elements s:*  *t:*

7. Mesh the wing surface.

**Mesh/Geometry/Surface...**

*<select all four front wing surfaces (top, bottom, and spar surfaces) - ID # 1, 2, 5, 6>*

**OK**

Property:

**1.. wing\_skin**

Node ID:

**2000**

Element ID:

**2000**

**OK**

Zoom in on the wing surface.

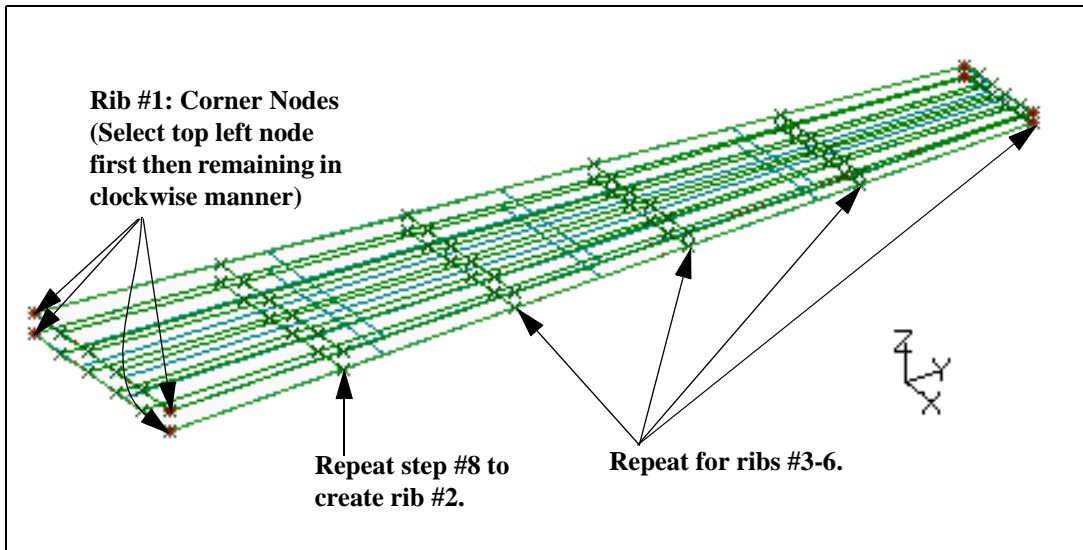
**View/Zoom... <F7>**

*<Select a window such that it encloses the wing>*

**OK**

The view should look like the following.

**Figure 11.2 - Wing surface meshed**



- 
8. Create a mesh between the top and bottom surfaces of the wing surface such that it would represent ribs.

**Mesh/Between... <Ctrl+B>**

Property:   
#Nodes, Dir 1:   
Dir 2:

Select the corner nodes as in figure 11-2. Your IDs may be different.

Corner nodes 1:   
Corner nodes 2:   
Corner nodes 3:   
Corner nodes 4:

Repeat for the rest of the ribs.

9. Mesh the tail surfaces and create the ribs. The process of creating ribs in the front wing surfaces will be used to create ribs in the rear tail surfaces.

Zoom out and zoom in on the tail wing.

**View/Unzoom**

**View/Zoom... <F7>**

*<Select a window such that it encloses the tail wing and the end of the fuselage>*

**Mesh/Geometry/Surface...**

*<select all four tail surfaces (top, bottom, and spar surfaces) - ID # 3, 4, 7, 8>*

Property:   
Node ID:   
Element ID:

**OK**

**Mesh/Between... <Ctrl+B>**

<i>Property:</i>	<input type="text" value="3.. rib"/>
<i>#Nodes, Dir 1:</i>	<input type="text" value="6"/>
<i>Dir 2:</i>	<input type="text" value="2"/>
<i>Corner nodes 1:</i>	<input type="text" value="3005"/>
<i>Corner nodes 2:</i>	<input type="text" value="3053"/>
<i>Corner nodes 3:</i>	<input type="text" value="3017"/>
<i>Corner nodes 4:</i>	<input type="text" value="3012"/>

**OK**

Continue the process until all the ribs on the tail are created.

- Equivalence the finite element mesh.

**Tools/Check/Coicident Nodes...**

**Select All**

**OK**

**No**

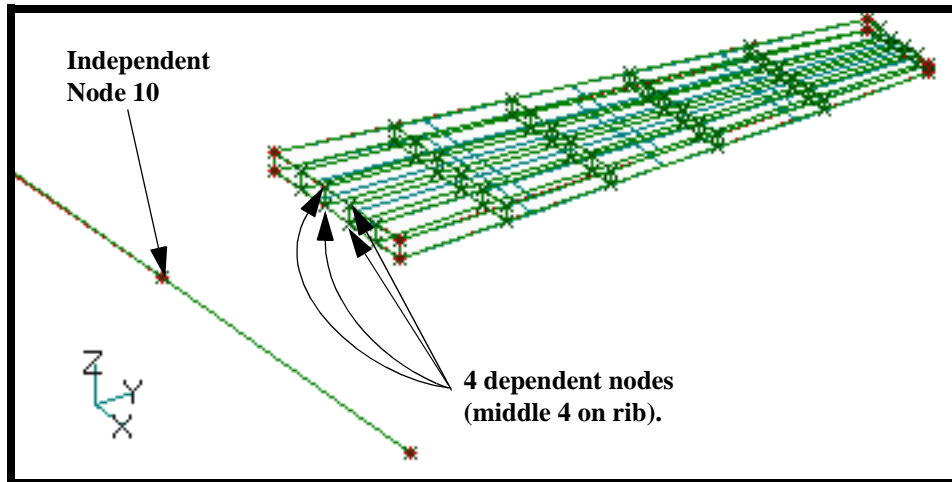
*Options:*

**Merge Coincident Entities**

**OK**

- Create rigid element to attach the wing and tail to the fuselage.

**Figure 11.3 - Creating rigid element to tail**



**Model/Element...**

Type...

Other Elements:

Rigid

OK

Independent: Node:

10

- TX  RX
- TY  RY
- TZ  RZ

Nodes...

<select 4 dependent nodes shown in Fig. 11-3 - ID # 3050, 3099, 3104, 3105>

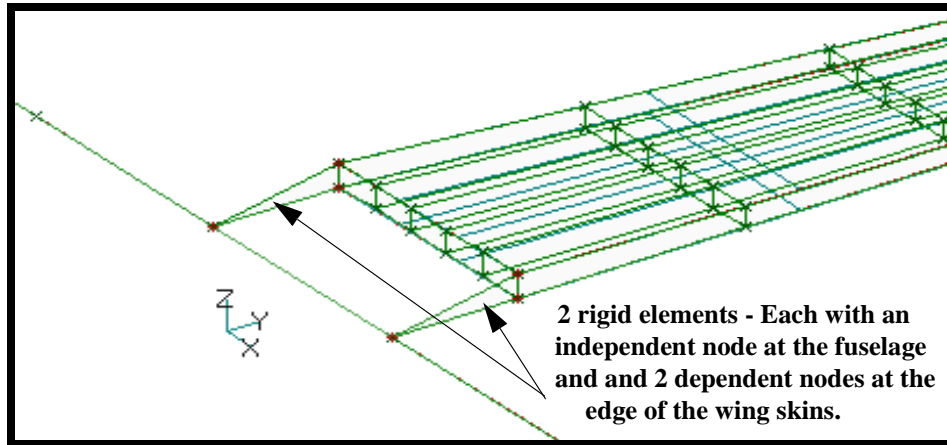
OK

OK

Cancel

Use the toolbar arrows and pan to the section where the front wing and fuselage are visible.

Figure 11.4 - Creating rigid elements to wing



Model/Element...

Independent: Node:

6

- TX    RX
- TY    RY
- TZ    RZ

Nodes...

<select 2 dependent nodes shown in Fig. 11-4 - ID # 2096, 2102>

OK

OK

Independent: Node:

7

- TX    RX
- TY    RY
- TZ    RZ

Nodes...

<select 2 dependent nodes shown in Fig. 11-4 - ID # 2101, 2107>

OK

OK

Cancel

---

**View/Autoscale <Ctrl+A>**

12. Create 2 sets of boundary conditions.

**Model/Constraint/Set...**

*Title:*

**symmetric**

**OK**

**Model/Constraint/Nodal...**

*<select all nodes on fuselage - ID # 1-4, 6, 7, 9, 10, 12>*

**OK**

**Y Symmetry**

**OK**

**Cancel**

**Model/Constraint/Set...**

*ID:*

**2**

*Title:*

**antisymmetric**

**OK**

**Model/Constraint/Nodal...**

**Previous**

**OK**

**Y AntiSym**

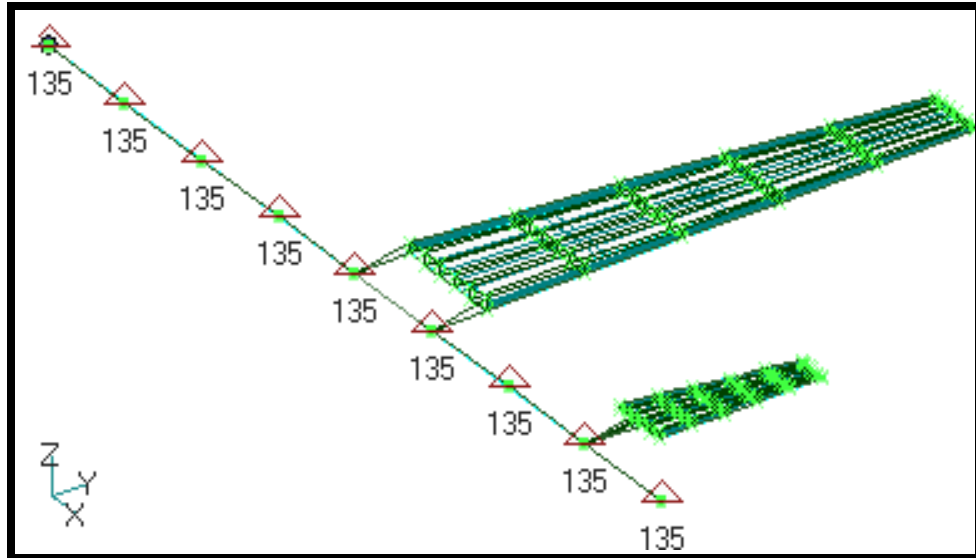
**OK**

**Cancel**

The model is now complete. It should look like the following picture

**View/Redraw <Ctrl+D>**

**Figure 11.5 - Completed Half Airplane Model**



13. Submit the file for analysis. Note that we will run both boundary conditions in a single run.

**File/Export/Analysis Model...**

Type:

**2.. Normal Modes/Eigenvalue**

**OK**

Filename:

**half\_aircraft**

**Write**

**Run Analysis**

**Advanced...**

We expect 3 rigid body modes so we request 8 modes to get 5 flexible modes.

Number Desired:

**8**

**OK**

**OK**

Unselect all output requests except displacement.

Output Requests:

**Displacement**

---

Unselect the constraint set for the master subcase.

*Analysis Case Requests:*

**Constraint (SPC) =**

**Write Case...**

**OK**

**Constraint (SPC) =**

**1.. symmetric**

**Write Case...**

**OK**

**Constraint (SPC) =**

**2.. antisymmetric**

**OK**

**OK**

**WTMASS**

**0.00259**

*PARAM:*

**PRGPST**

**OK**

**Yes**

Save the model.

*Filename:*

**half\_aircraft**

**Save**

**Continue**

14. Postprocess the results.

**Ctrl+Q**

**All Entities Off**

**Elements**

**Done**

**View/Select... <F5>**

*Model Style:*

**Quick Hidden Line**

*Deformed Style:*

**Deform**

*Contour Style:*

**Contour**

**Deformed and Contour Data...**

Use the pulldown menus to make the following selections.

*Output Set:*

**1.. Mode 1,**

*Deformation:*

**1.. Total Translation**

*Contour:*

**4.. T3 Translation**

**OK**

**OK**

View each mode in turn. To go through the modes, use the right hand tool bar



then



---

<b>Mode</b>	<b>Symmetric</b>	<b>Antisymmetric</b>
<b>1</b>	<b>0</b>	<b>0</b>
<b>2</b>	<b>0</b>	<b>0</b>
<b>3</b>	<b>0</b>	<b>0</b>
<b>4</b>	<b>2.45342</b>	<b>6.968212</b>
<b>5</b>	<b>9.764751</b>	<b>9.755774</b>
<b>6</b>	<b>11.05749</b>	<b>19.0465</b>
<b>7</b>	<b>18.83449</b>	<b>19.25484</b>
<b>8</b>	<b>24.47528</b>	<b>25.47031</b>