

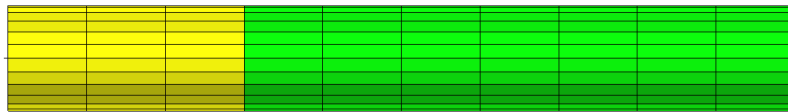
# Workshop - Model Matching / System Identification

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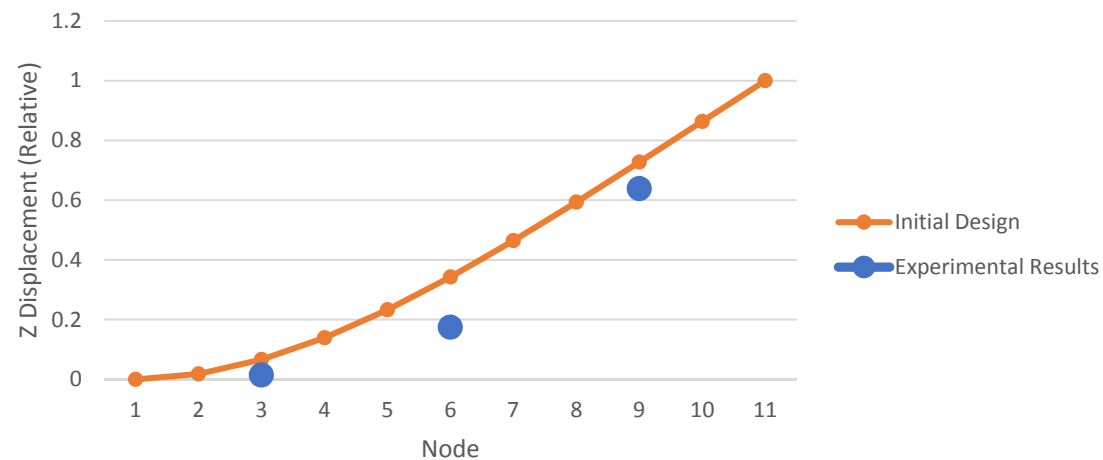
AN MSC NASTRAN SOL 200 TUTORIAL

# Goal: Use optimization correlate test data and analysis results

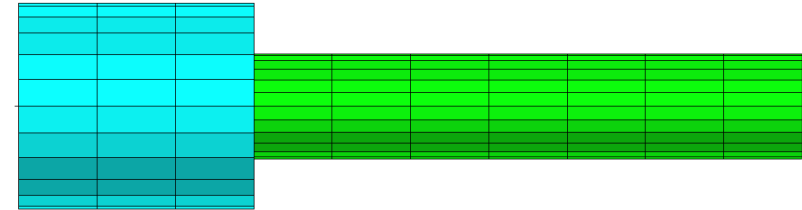
Before Optimization  
Radius: 2 in



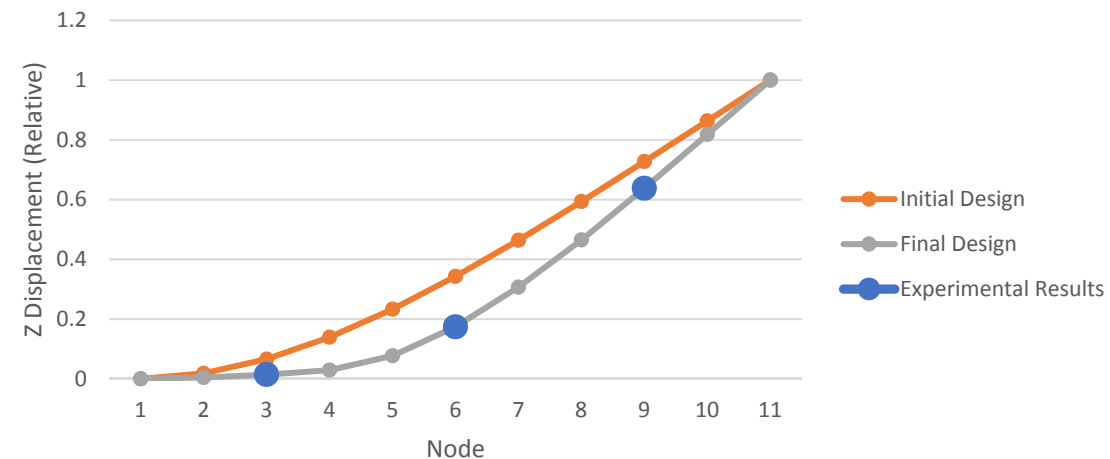
Mode 1 (First Bending Mode)



After Optimization  
◦ Radius 3.93 in



Mode 1 (First Bending Mode)



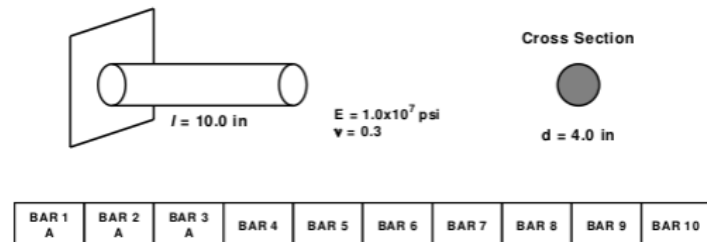
# Details of the structural model

## 25.6.6 System Identification

An important area of research is the tuning of finite element models to experimental test results. This is often called system identification. This example problem illustrates how optimization may be used to address these requirements. It features:

- ❑ Normal modes optimization
- ❑ Constraints on RMS error in mode shapes
- ❑ Frequency constraints
- ❑ Using an analytical response as the objective

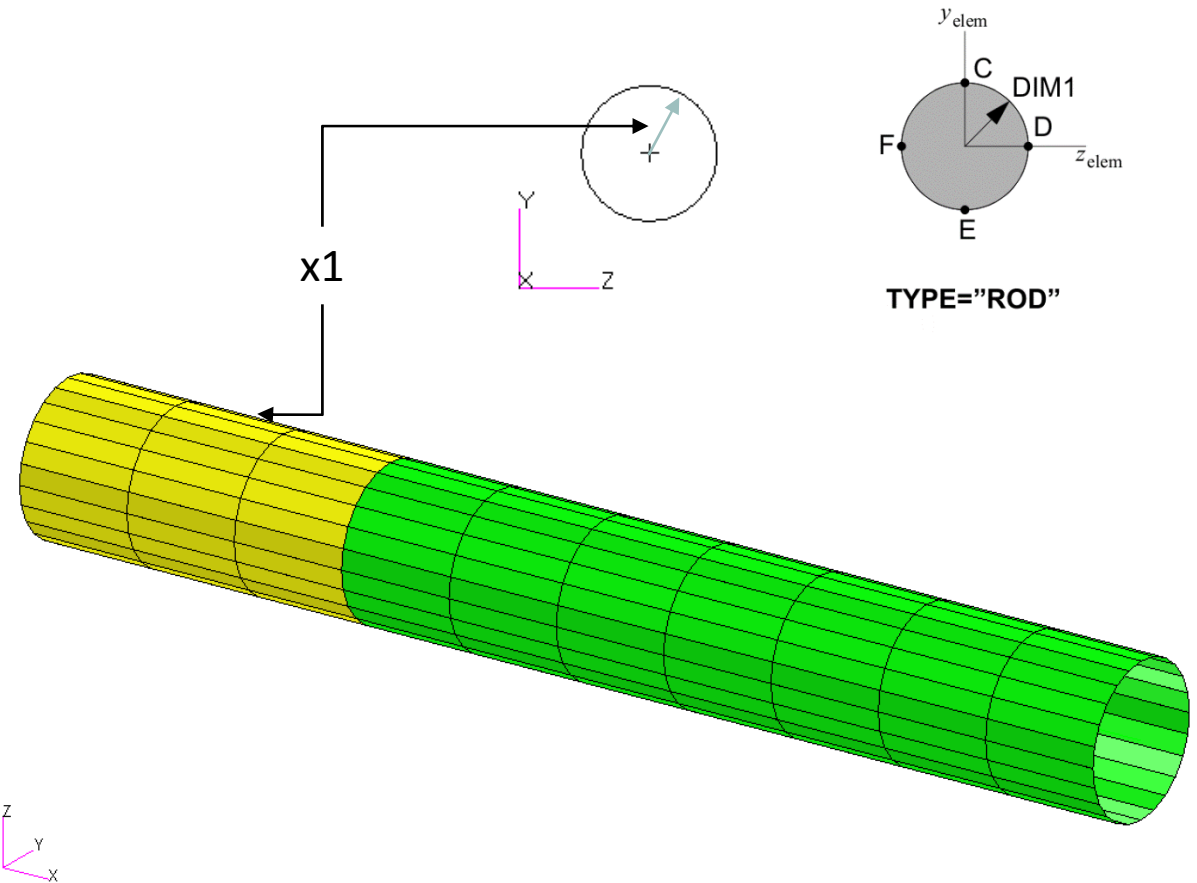
Figure 25-13. SYSTEM ID — SIMPLE BEAM MODEL



25-72 MULTIDISCIPLINARY DESIGN OPTIMIZATION

UAI/NASTRAN

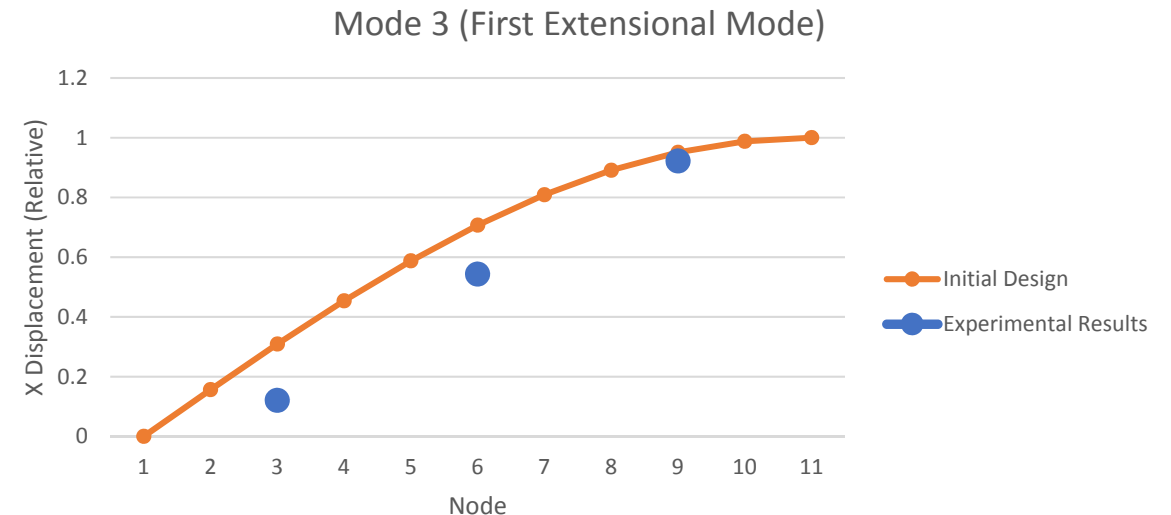
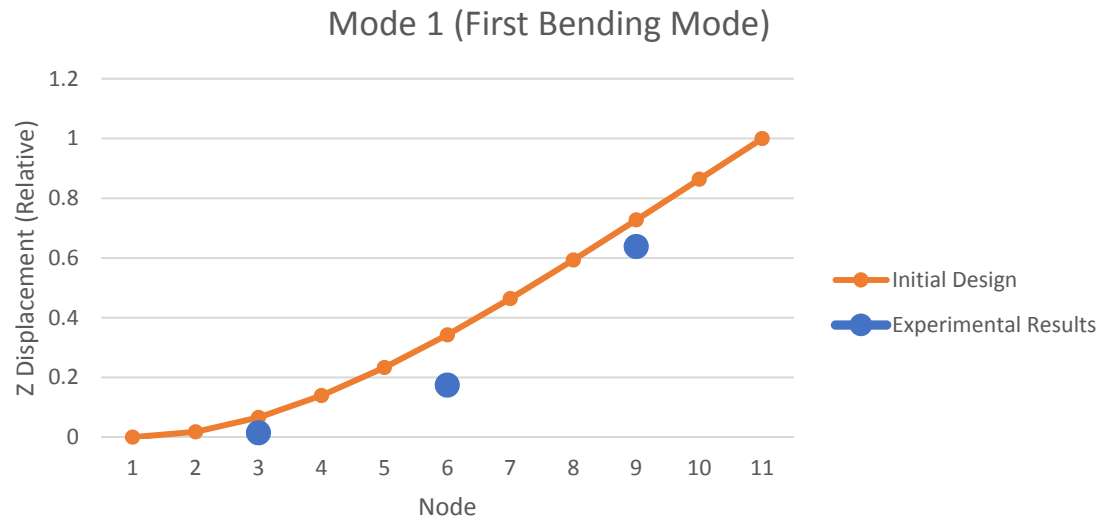
UAI/NASTRAN User's Guide for Version 20.1  
Chapter 25 - MULTIDISCIPLINARY DESIGN OPTIMIZATION -  
25.6.6 System Identification



# Details of the structural model

## Experimental Results

	Mode 1		Mode 3	
Node	Component	Experimental Value	Component	Experimental Value
3	z or 3 direction	0.0143	x or 1 direction	0.1204
6	z or 3 direction	0.1741	x or 1 direction	0.5431
9	z or 3 direction	0.6381	x or 1 direction	0.9216

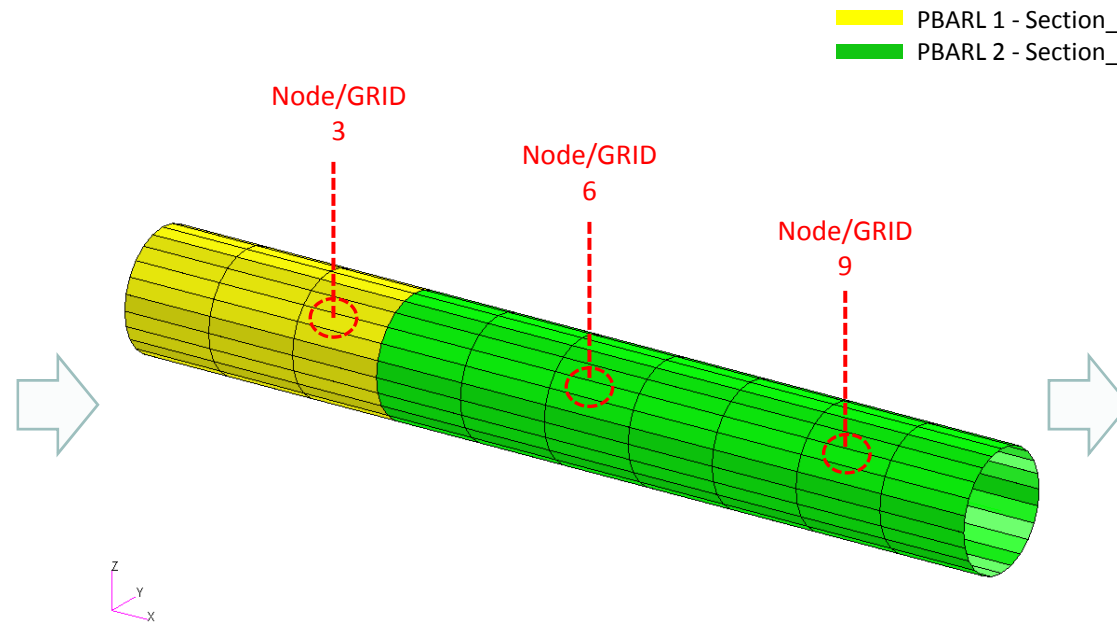


# Optimization Problem Statement

## Design Variables

x1: Radius of cross section (DIM1 of PBARL 1)

$$.1 < x1 < 10.$$



## Design Objective, Equation

R0: Minimize

$$\left(\frac{a1-.0143}{.0143}\right)^2 + \left(\frac{a2-.1741}{.1741}\right)^2 + \left(\frac{a3-.6381}{.6381}\right)^2$$

- a1: 3<sup>rd</sup> component of relative displacement for mode 1 at grid 3
- a2: 3<sup>rd</sup> component of relative displacement for mode 1 at grid 6
- a3: 3<sup>rd</sup> component of relative displacement for mode 1 at grid 9

## Design Constraints, Equation

$$R1 = \left(\frac{a4-.1204}{.1204}\right)^2 \quad R1 < .001$$

$$R2 = \left(\frac{a5-.5431}{.5431}\right)^2 \quad R2 < .001$$

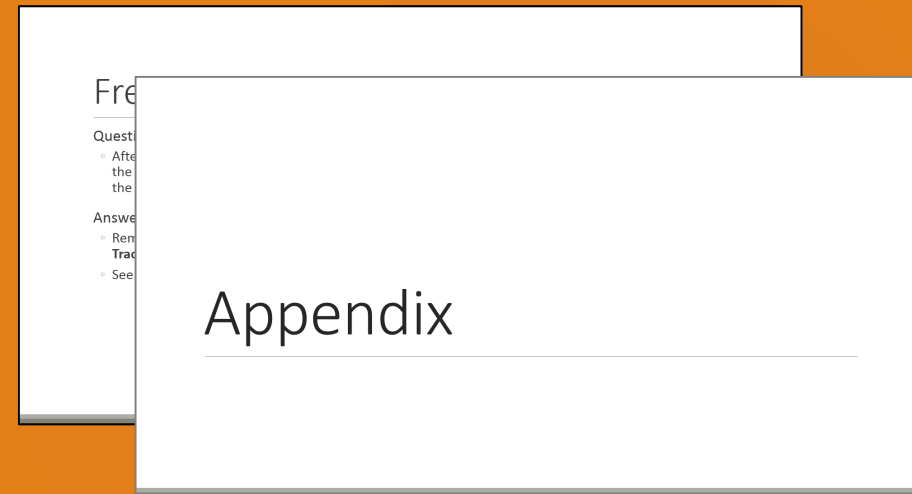
$$R3 = \left(\frac{a6-.9216}{.9216}\right)^2 \quad R3 < .001$$

- a4: 1<sup>st</sup> component of relative displacement for mode 3 at grid 3
- a5: 1<sup>st</sup> component of relative displacement for mode 3 at grid 6
- a6: 1<sup>st</sup> component of relative displacement for mode 3 at grid 9

# More Information Available in the Appendix

The Appendix includes information regarding the following:

- Frequently Asked Questions
  - After performing the example, the solution is different from the tutorial. What happened?



# Contact me

- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural or mechanical optimization questions
- Access to the SOL 200 Web App

christian@ the-engineering-lab.com

# Tutorial

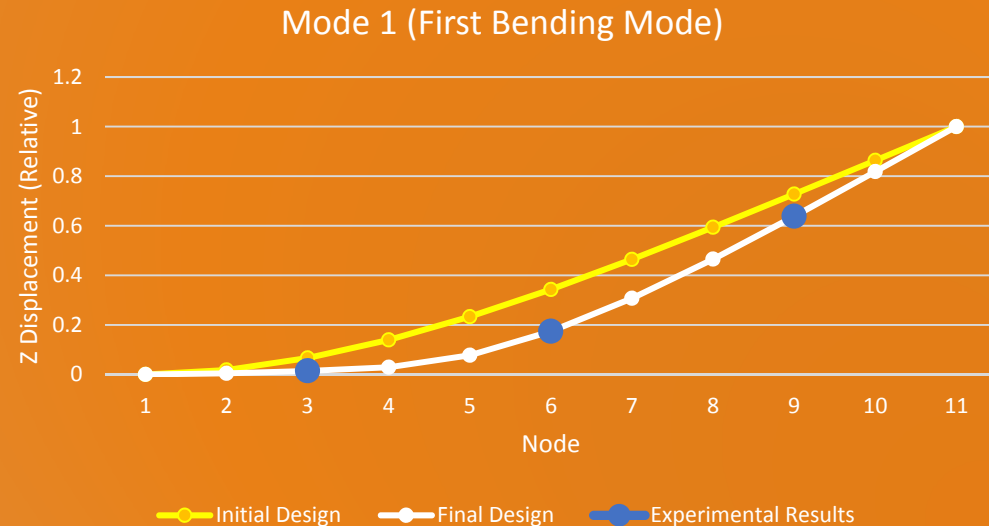
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# Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
  - Convert the .bdf file to SOL 200
  - Design Variables
  - Design Objective
  - Design Constraints
  - Perform optimization with Nastran SOL 200
3. Plot the Optimization Results
4. Update the original model with optimized parameters

## Special Topics Covered

**Model Matching** - The SOL 200 Web App features a single table where the model matching problem can be defined. In the background, the necessary objective and constraints are automatically generated. In addition, plots comparing the final and target values are auto generated.



# SOL 200 Web App Capabilities

The Post-processor Web App and HDF5 Explorer are free to MSC Nastran users.

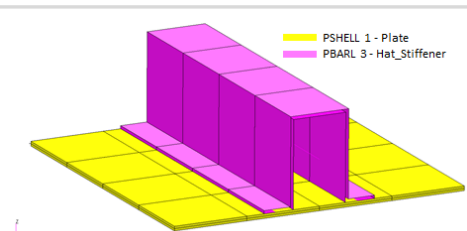
## Compatibility

- Google Chrome, Mozilla Firefox or Microsoft Edge
- Windows and Red Hat Linux
- Installable on a company laptop, workstation or server. All data remains within your company.

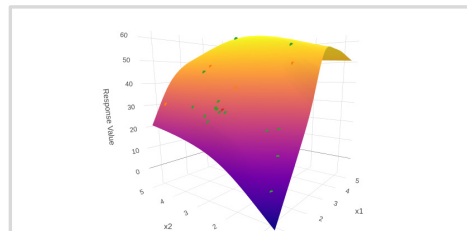
## Web Apps

## Benefits

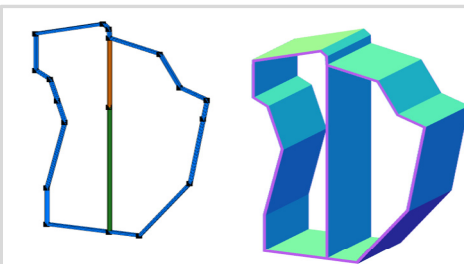
- REAL TIME error detection. 200+ error validations.
- REAL TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials



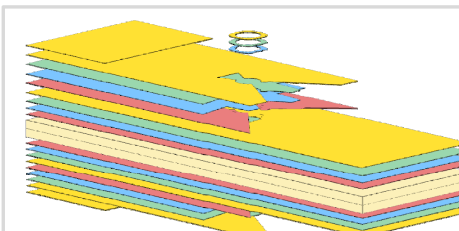
**Web Apps for MSC Nastran SOL 200**  
Pre/post for MSC Nastran SOL 200.  
Support for size, topology, topometry, topography, multi-model optimization.



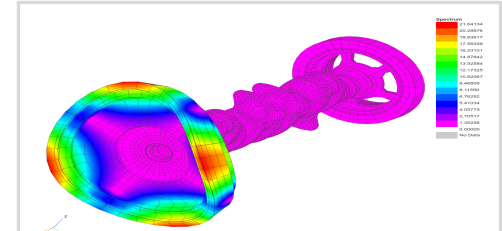
**Machine Learning Web App**  
Bayesian Optimization for nonlinear response optimization (SOL 400)



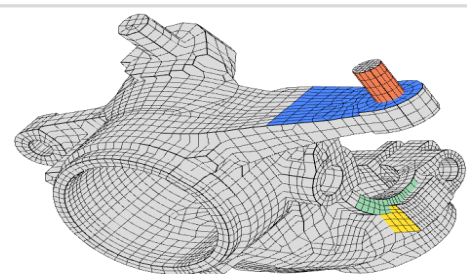
**PBMSECT Web App**  
Generate PBMSECT and PBRSECT entries graphically



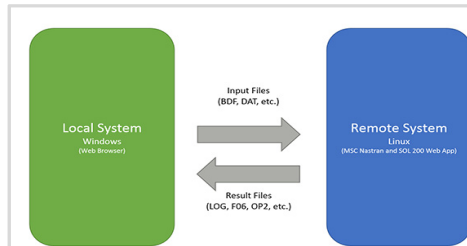
**Ply Shape Optimization Web App**  
Optimize composite ply drop-off locations, and generate new PCOMP entries



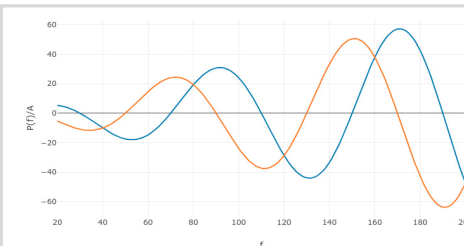
**Post-processor Web App**  
View MSC Nastran results in a web browser on Windows and Linux



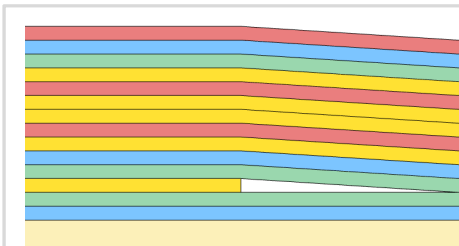
**Shape Optimization Web App**  
Use a web application to configure and perform shape optimization.



**Remote Execution Web App**  
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



**Dynamic Loads Web App**  
Generate RLOAD1, RLOAD2 and DLOAD entries graphically



**Stacking Sequence Web App**  
Optimize the stacking sequence of composite laminate plies

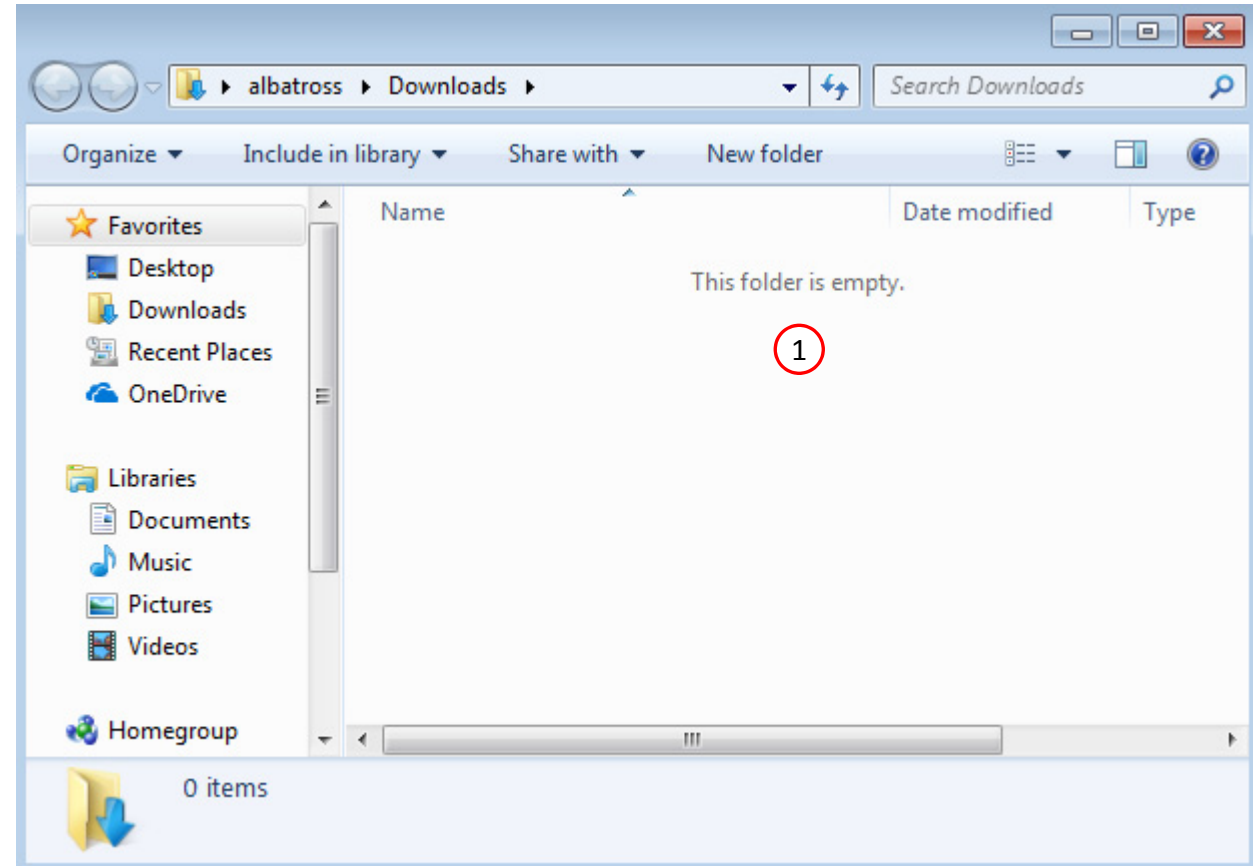


**HDF5 Explorer Web App**  
Create graphs (XY plots) using data from the H5 file

# Before Starting

1. Ensure the Downloads directory is empty in order to prevent confusion with other files

- Throughout this workshop, you will be working with multiple file types and directories such as:
  - .bdf/.dat
  - nastran\_working\_directory
  - .f06, .log, .pch, .h5, etc.
- To minimize confusion with files and folders, it is encouraged to start with a clean directory.



# Go to the User's Guide

1. Click on the indicated link

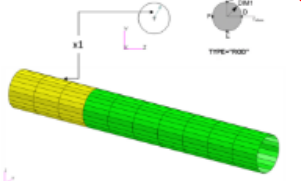
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

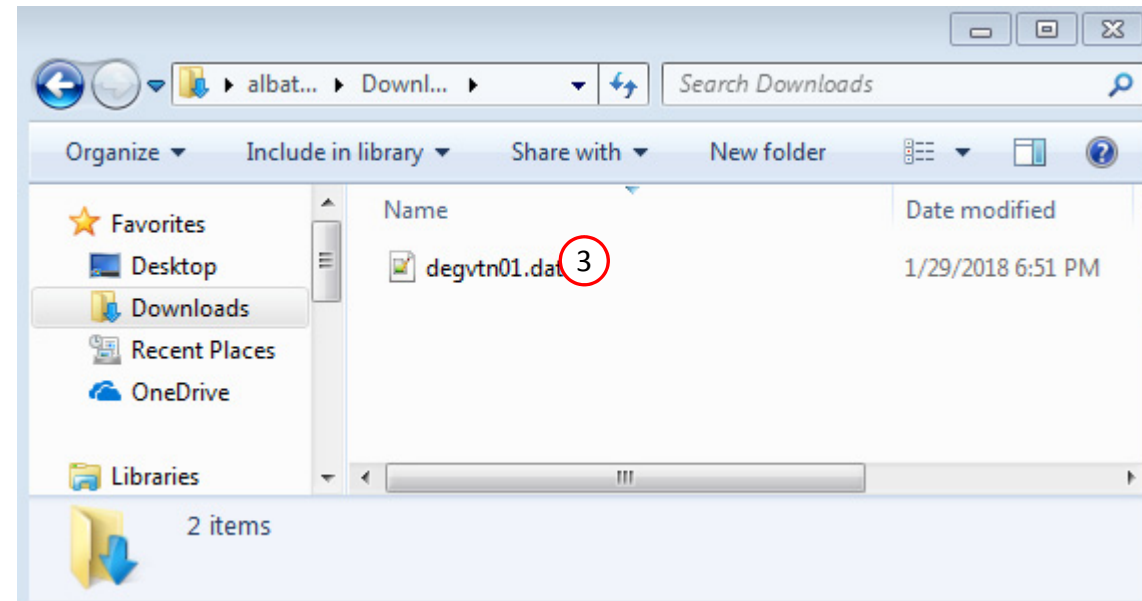


# Obtain Starting Files

1. Find the indicated example
2. Click Link
3. The starting file has been downloaded

- When starting the procedure, all the necessary BDF files must be collected together.

	<p><b>1</b> Using MSC Nastran Optimization for Model Matching / System Identification</p> <p>In this example, the cross section of a rod is designed such that the analysis modes match experimentally measured data. MSC Nastran Optimization is used to minimize the root sum of squares for Mode 1.</p> <p>This example is an adaptation of the example found in the UAI/Nastran User's Guide for Version 20.1 - 252.6.6 System Identification. The following is an excerpt from the guide describing this example. Keep in</p>	<a href="#">Link</a>
	<p>The design model is simple having a single design variable which represents the root cross-sectional area."</p> <p>— UAI/Nastran User's Guide for Version 20.1 - 252.6.6 System Identification</p> <p>Starting BDF Files: <a href="#">Link</a> <b>2</b> Solution BDF Files: <a href="#">Link</a></p>	



# Open the Correct Page

1. Click on the indicated link

- MSC Nastran can perform many optimization types. The SOL 200 Web App includes dedicated web apps for the following:
  - Optimization for SOL 200 (Size, Topology, Topometry, Topography, Local Optimization, Sensitivity Analysis and Global Optimization)
  - Multi Model Optimization
  - Machine Learning
- The web app also features the HDF5 Explorer, a web application to extract results from the H5 file type.



# Upload BDF Files

1. Click 1. Select Files and select degvtn01.dat
2. Click Upload Files

- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.

## Step 1 - Upload .BDF Files

The screenshot shows a two-step process for uploading files. Step 1, '1. Select files', is highlighted with a red circle and shows a file named 'degvtn01.dat' selected. Below this, a green progress bar indicates 'Inspecting: 100%'. Step 2, '2. Upload files', is also highlighted with a red circle and shows a green progress bar indicating 'Uploading: 100 %'. At the bottom, there is a checkbox labeled 'List of Selected Files' which is currently unchecked.

1. Select files degvtn01.dat

Inspecting: 100%

2. Upload files

Uploading: 100 %

☐ List of Selected Files

# Create Design Variables

1. Type dim into the search bar
2. Click on the plus (+) icons to set DIM1 as a design variable
3. Specify the lower bound as .1 for design variables x1
4. Specify the upper bound as 10. for design variables x1

- Each step has hidden functionality for advanced users. The visibility is controlled by clicking **+ Options**.
- If the property entry, e.g. PSHELL, was given a name in Patran, e.g. Car Door, the name can be shown by marking the checkbox titled Entry Name.

## Step 1 - Select design properties

+ Options

Create DVXREL1	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Current Value ⇅
	dim <b>1</b>	Search	Search	Search	Search
<b>2</b> +	DIM1	ROD - Radius	PBARL	1	2.
+	DIM1	ROD - Radius	PBARL	2	2.

5 10 20 30 40 50  
Number of Visible Rows 5

## Step 2 - Adjust design variables

✕ Delete Visible Rows

+ Options

	Label ⇅	Status ⇅	Property ⇅	Property Description ⇅	Entry ⇅	Entry ID ⇅	Initial Value ⇅	Lower Bound	Upper Bound	Allowed Discrete Values
	Search	Search	Search	Search	Search	Search	Search	Search	Search	Search
✕	x1	☑	DIM1	ROD - Radius	PBARL	1	2.	.1 <b>3</b>	10. <b>4</b>	Examples: -2.0, 1.0, THRU, 10.0, BY, 1.0

# Create Responses

1. Click on Objective
2. Click on Equation Objective

- The responses that are used for model matching must be defined. The response can be defined in the table titled “Step A – Optional – Create additional responses.” This table is accessible by first clicking the button titled “Switch to Equation Objective.”

SOL 200 Web App - Optimization   Upload   Variables   **Objective**   Constraints   Subcases   Exporter   Results






Objective   **Equation Objective**

### Step 1 - Select an objective

Select an analysis type

SOL 101 - Statics

Select a response

	Response Description	Response Type
	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	Weight	WEIGHT
	Volume	VOLUME
	Displacement	DISP
	Strain	STRAIN
	Element Strain Energy	ESE

# Create Responses

1. Scroll down the page until you find section: Step A - Optional - Create additional responses
2. Click 3 times on the Displacement response to create responses: a1, a2 and a3
3. Configure the constraints as shown to the right
  - Example: Configure the following for a1
    - ATTA: 3 - T3 - Rectangular z
    - ATTB: 1 (mode 1)
    - ATTi: 3 (grid/node 3)
  - Repeat the same for a2 and a3 but note that ATTi will be different for each row
  - These 3 responses correspond to the displacement of mode shape 1 at three grids in the 3/T3/z direction.

## 1 Step A - Optional - Create additional responses

Select an analysis type

SOL 103 - Normal Modes

Select a response

	Response Description ⇅	Response Type ⇅
	Search	Search
+	Weight	WEIGHT
+	Volume	VOLUME
+	Eigenvalue	EIGN
+	Frequency	FREQ
2 +	Displacement	DISP

« 1 2 3 »

5 10 20 30 40 50

## Step B - Optional - Adjust responses

+ Options

	Label ⇅	Status ⇅	Response Type ⇅	Property Type ⇅	ATTA ⇅	ATTB ⇅	ATTi ⇅
	Se	Seal	Search	Search	Search	Search	Search
✗	a1	✓	DISP		3 - T3 (Rectangular z, Cylindrical z ▼	1	3
✗	a2	✓	DISP		3 - T3 (Rectangular z, Cylindrical z ▼	1	6
✗	a3	✓	DISP		3 - T3 (Rectangular z, Cylindrical z ▼	1	9

# Create Responses

- Click 3 times on the Displacement response to create responses: a4, a5 and a6
- Click 10 on the pagination bar
- Configure the constraints as shown to the right
  - Example: Configure the following for a4
    - ATTA: 1 – T1 - Rectangular x
    - ATTB: 3 (mode 3)
    - ATTi: 3 (grid/node 3)
  - Repeat the same for a5 and a6 but note that ATTi will be different for each row

- The next 3 responses correspond to the displacement of mode shape 3 at three grids in the 1/T1/x direction.

## Step A - Optional - Create additional responses

Select an analysis type

SOL 103 - Normal Modes

Select a response

	Response Description ▾	Response Type ▾
	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	Weight	WEIGHT
	Volume	VOLUME
	Eigenvalue	EIGN
	Frequency	FREQ
<b>1</b>	Displacement	DISP

« 1 2 3 »

5 10 20 30 40 50

## Step B - Optional - Adjust responses

+ Options

	Label ▾	Status ▾	Response Type ▾	Property Type ▾	ATTA ▾	ATTB ▾	ATTi ▾
	<input type="text" value="St"/>	<input type="text" value="Seal"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>	<input type="text" value="Search"/>
	a1		DISP		3 - T3 (Rectangular z, Cylindrical z ▾)	1	3
	a2		DISP		3 - T3 (Rectangular z, Cylindrical z ▾)	1	6
	a3		DISP		3 - T3 (Rectangular z, Cylindrical z ▾)	1	9
	a4		DISP		<b>3</b> 1 - T1 (Rectangular x, Cylindrical r ▾)	3	3
	a5		DISP		1 - T1 (Rectangular x, Cylindrical r ▾)	3	6
	a6		DISP		1 - T1 (Rectangular x, Cylindrical r ▾)	3	9

5 10 20 30 40 50

# Configure Model Matching

1. Click Match
2. Configure the target values as shown
3. Mark the 3 checkboxes
4. Remove any maximum allowed errors, the input boxes should be blank
5. Specify the maximum allowed error as .001

- The necessary objective and constraints are automatically generated. Refer to the Equation Objective and Equation Constraint sections.

SOL 200 Web App - Optimization   Upload   Variables   Objective   Constraints   Subcases   Exporter   Results   Settings   **Match**   Other   User's Guide   Home

Step 1 - Configure model matching

+ Options

Status ▾	Label ▾	Single Scalar? ▾	Description ▾	Target Value ▾	Include in Objective ▾	Max Allowed Error ▾
Search	Search	Search	Search	Search	Search <b>3</b>	Search <b>4</b>
<input checked="" type="checkbox"/>	a1	Yes	T3 component(s) of displacement at grid 3 of mode 1	.0143	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a2	Yes	T3 component(s) of displacement at grid 6 of mode 1	.1741	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a3	Yes	T3 component(s) of displacement at grid 9 of mode 1	.6381	<input checked="" type="checkbox"/>	Example: -100.1
<input checked="" type="checkbox"/>	a4	Yes	T1 component(s) of displacement at grid 3 of mode 3	.1204	<input type="checkbox"/>	.001
<input checked="" type="checkbox"/>	a5	Yes	T1 component(s) of displacement at grid 6 of mode 3	.5431	<input type="checkbox"/>	.001
<input checked="" type="checkbox"/>	a6	Yes	T1 component(s) of displacement at grid 9 of mode 3	.9216	<input type="checkbox"/>	.001

**2**   **5**

# Configure Settings

1. Click Settings
2. Scroll to section Result Files
3. Select one of the following H5 output options
  - Create the H5 file with MDLPRM
  - Create the H5 file with HDF5OUT

- The H5 file is used by the Post-processor web app to display MSC Nastran results.
- The H5 file is used by the HDF5 Explorer to create graphs (XY Plots) of MSC Nastran results.

The screenshot shows the 'SOL 200 Web App - Optimization' interface. The 'Settings' tab is selected, indicated by a red circle with the number '1'. Below the navigation bar, the 'Result Files' section is highlighted with a red circle and the number '2'. Within this section, the 'H5 Output Option' dropdown menu is open, showing three options: 'Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)', 'Create the H5 file with MDLPRM (supported in MSC Nastran 2016.1 or newer)', and 'Create the H5 file with HDF5OUT (supported in MSC Nastran 2022.2 or newer)'. The third option is selected and highlighted in blue, with a red circle and the number '3' next to it. A red rectangle also encloses the entire dropdown menu area. On the right side of the interface, there is a 'BDF Output' section with a list of parameters including '\$', '\$', '\$', '\$', '\$', 'DOPTPRM', 'DESM', '\$ Parameter t', and 'HDF5OUT INPUT'.

1. Click on Exporter
2. Click on Download BDF Files

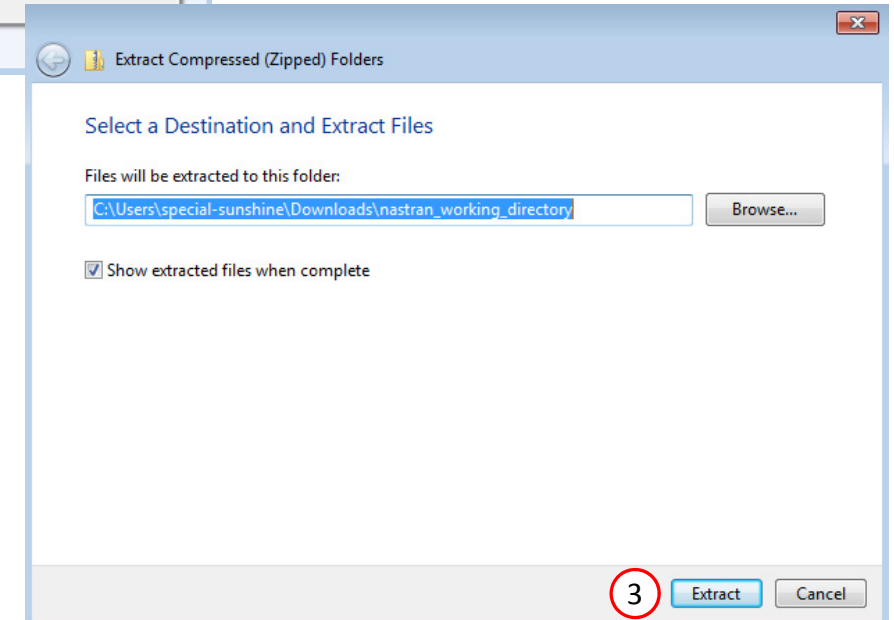
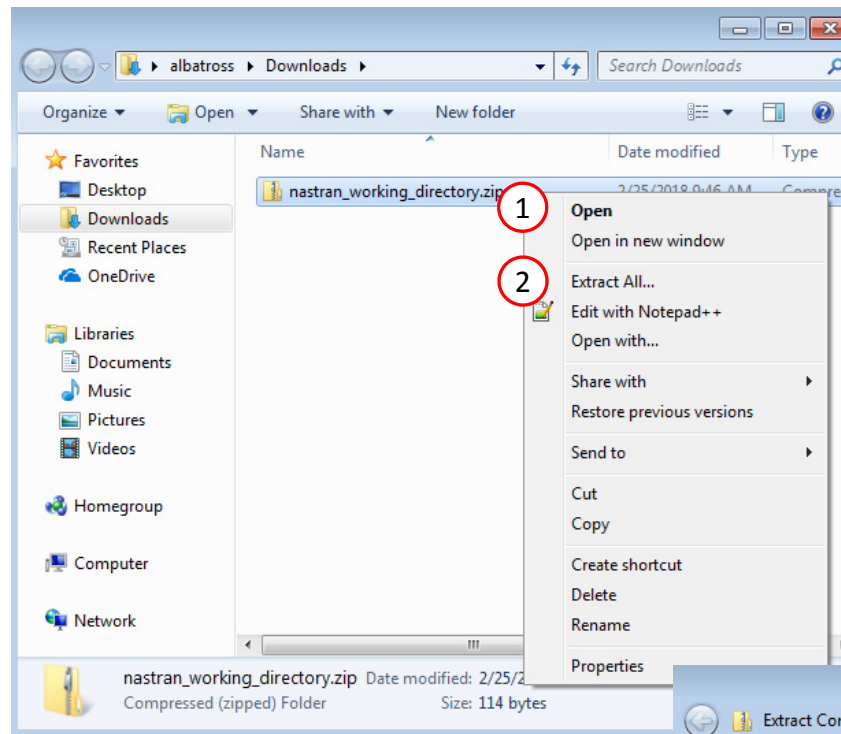
- When the download button is clicked a new file named “nastran\_working\_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran\_working\_directory (1).zip”

Questions? Email: [christian@the-engineering-lab.com](mailto:christian@the-engineering-lab.com)

# Perform the Optimization with Nastran SOL 200

1. A new .zip file has been downloaded
2. Right click on the file
3. Click Extract All
4. Click Extract on the following window

- Always extract the contents of the ZIP file to a new, empty folder.



# Inspect the BDF File for Mode Tracking

The web has automatically inserted the MODTRAK lines, which triggers mode tracking when the optimization is performed by MSC Nastran. Visually inspect the BDF files to verify the MODTRAK lines are present.

1. Open both model.bdf and design\_model.bdf in a text editor
2. Ensure the MODTRAK command is in SUBCASE 1001
3. Ensure the MODTRAK entry is in the Bulk Data Section

- The mode numbers of specific mode shapes may vary during the optimization. For example, if mode 3 is a flexural mode and its natural frequency increases during the optimization, its mode number may change to a higher value. To ensure the optimizer tracks the mode shape of interest, mode tracking is employed.

1

```
Z:\20210701_workshop_material_size\files\ws_degytn01\2_solution_files\design_model.bdf - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

model.bdf x design_model.bdf x
1 assign userfile = 'optimization_results.csv', status =
2 form = formatted, unit = 52
3 ID MSC, DEGVN01 $ NEW FOR V2002 LWO0 2/1/02
4 $ Modified 3-Aug-2005 David Chou v2006
5 TIME 100
6 DIAG 6,8
7 SOL 200
8 CEND
9
10 $
11 TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
12 SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
13 $
14 $ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
15 $ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
16 $ COMPUTED MODES AND ACTUAL MODES
17 $
18 $
19 SPC = 1
20 $
21 DESOBJ(MIN) = 9000000
22 $ DESGLB Slot
23 $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
24 SUBCASE 1001
25 ANALYSIS = MODES
26 DESSUB = 40001001
27 $ DRSPAN Slot
28 MODTRAK = 800 2
29 DISP = ALL
30 METHOD = 1
31 $
32 BEGIN BULK
33 INCLUDE './design_model.bdf'
34

107 $
108 $ 1 || 2 || 3 || 4 || 5 || 6 || 7
109 $DCONADD DCID DC1 DC2 DC3 etc.
110 DCONADD 40001001 50000015000002 5000003
111
112
113 $
114 $
115 $ Optimization Control Settings
116 $ 1 || 2 || 3 || 4 || 5 || 6 || 7
117 $DOPTPRM PARAM1 VAL1 PARAM2 VAL2 PARAM3 VAL3
118
119 DOPTPRM DESMAX 20 P1 1 P2 15
120
121
122
123
124 $
125 $ Parameter that supports output of CSV
126 PARAM XYUNIT 52
127 $ Parameter that supports punch file (.pch) output
128 PARAM DESPCH1 -1
129
130 $ The following line is exactly 80 columns
131 $ 1 || 2 || 3 || 4 || 5 || 6 || 7
132
133 $ Mode Tracking Parameter
134 MODTRAK 800 1 100 .9 3
135
136
137
138 $ urlUsed: http://localhost:8080/optimization/
139 $ Use Match: 6000001, 6000002, 6000003, 6000004, 6000
140 $LCOMM x1 DIM1, ROD - Radius, of PBARL 1 (Secti
```

# Perform the Optimization with Nastran SOL 200

1. Inside of the new folder, double click on Start MSC Nastran
2. Click Open, Run or Allow Access on any subsequent windows
3. MSC Nastran will now start

- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  - 1) Copy the BDF files and the INCLUDE files to a remote machine.
  - 2) Run the MSC Nastran job on the remote machine.
  - 3) After completion, copy the BDF, F06, LOG, H5 files to the local machine.
  - 4) Click "Start MSC Nastran" to display the results.

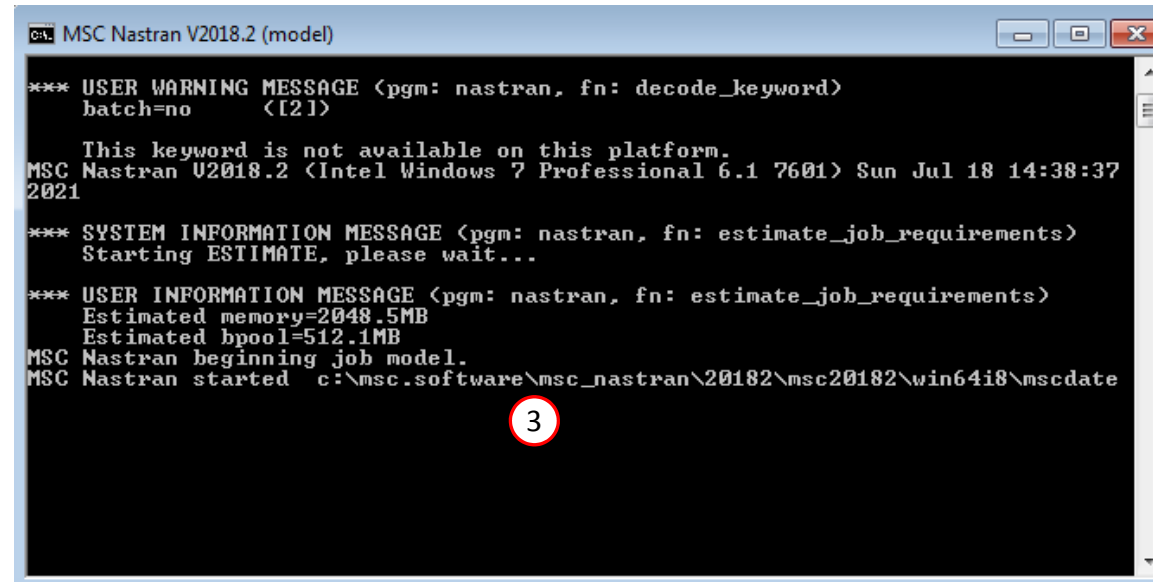
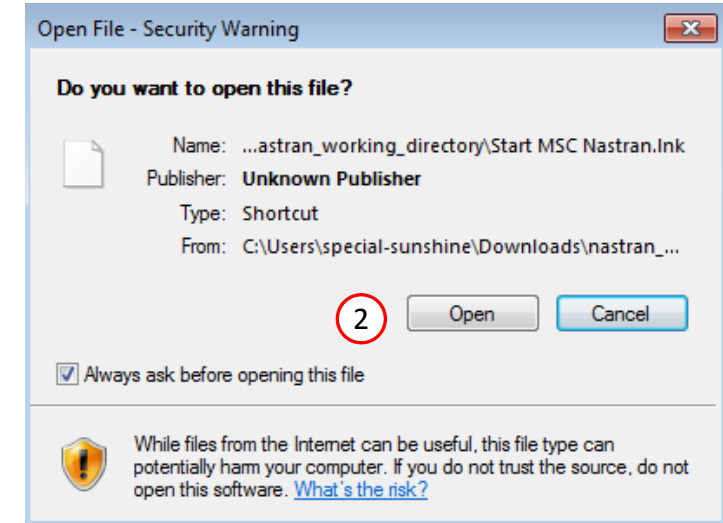
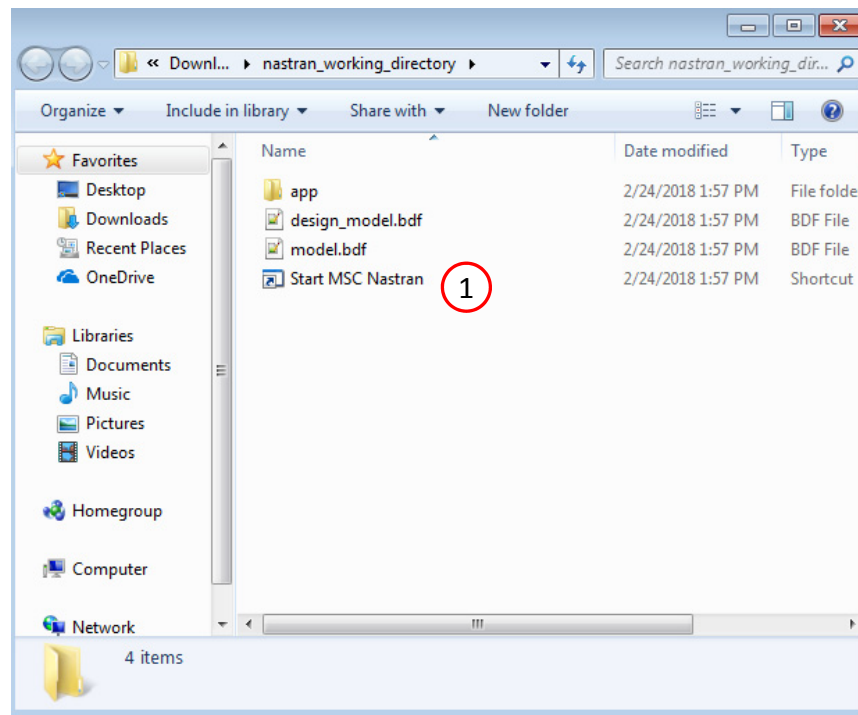
## Using Linux?

Follow these instructions:

- 1) Open Terminal
- 2) Navigate to the nastran\_working\_directory  
`cd ./nastran_working_directory`
- 3) Use this command to start the process  
`./Start_MSC_Nastran.sh`

In some instances, execute permission must be granted to the directory. Use this command. This command assumes you are one folder level up.

```
sudo chmod -R u+x ./nastran_working_directory
```




# Status

1. While MSC Nastran is running, a status page will show the current state of MSC Nastran

- The status of the MSC Nastran job is reported on the Status page. Note that Windows 7 users will experience a delay in the status updates. All other users of Windows 10 and Red Hat Linux will see immediate status updates.

## SOL 200 Web App - Status

 Python

 MSC Nastran

### Status

Name	Status of Job	Design Cycle	RUN TERMINATED DUE TO
model.bdf	Running	None	

# Review Optimization Results

After MSC Nastran is finished, the results will be automatically uploaded.

1. Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
2. The final value of objective, normalized constraints (not shown) and design variables can be reviewed.

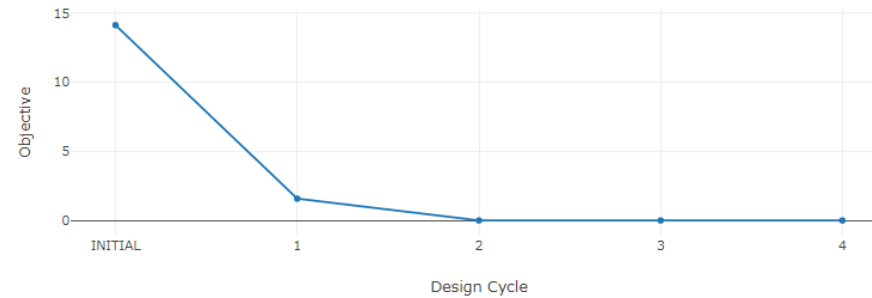
- After an optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- In the event the your results do not match the results documented, refer to the Appendix. See the Frequently Asked Questions – “After performing the example, the solution is different from the tutorial. What happened?”

## Final Message in .f06

1

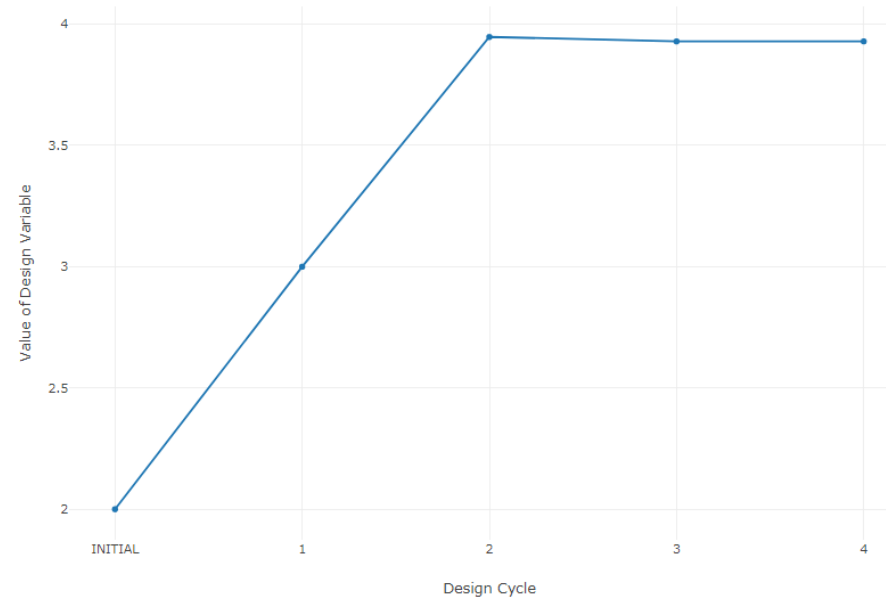
✓ RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 4.

## Objective



2

## Design Variables



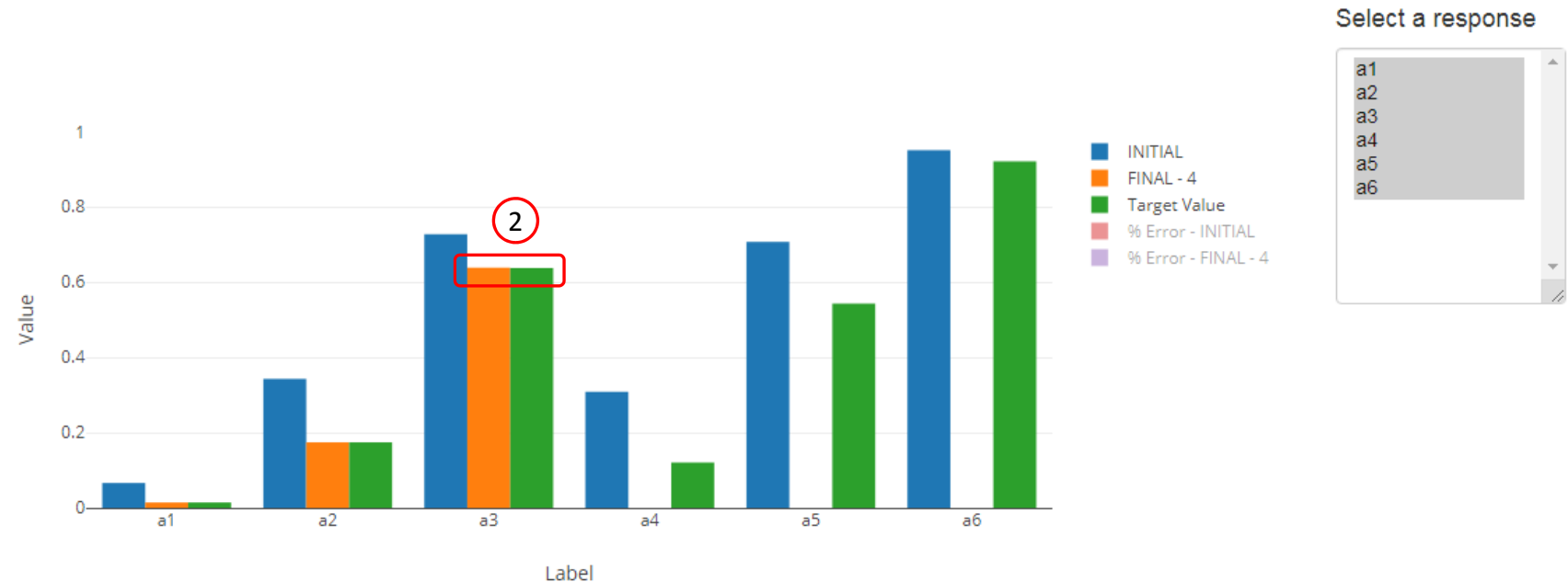
# Review Optimization Results

1. If "Option 1 – Auto Execute MSC Nastran" was used, bar charts will automatically be generated.
2. These charts can be used to compare the final values of the responses and the target values.

A. The Bar Charts report the following values for each response/label: The original/initial value, the final value after optimization, the target value, and the percent errors of the initial and final design.

B. If the bars for both final and target values are equally leveled, the indicates an exact correlation. Alternatively the percent errors are listed in the table and may be used to gauge the success of the model matching.

## 1 Model Matching Bar Charts



Design Cycle	a1	a2	a3	a4	a5
A	T3 component(s) of displacement at grid 3 of mode 1	T3 component(s) of displacement at grid 6 of mode 1	T3 component(s) of displacement at grid 9 of mode 1	T1 component(s) of displacement at grid 3 of mode 3	T1 component(s) of displacement at grid 6 of mode 3
INITIAL	6.6205E-02	3.4278E-01	7.2745E-01	3.0902E-01	7.071
FINAL - 4	1.4299E-02	1.7412E-01	6.3826E-01	Not reported in F06**	Not reported
Target Value	1.4300E-2	1.7410E-1	6.3810E-1	1.2040E-1	5.431
% Error - INITIAL	362.97	96.89	14.00	156.66	30.20
% Error - FINAL - 4	B -0.01	0.01	0.03		

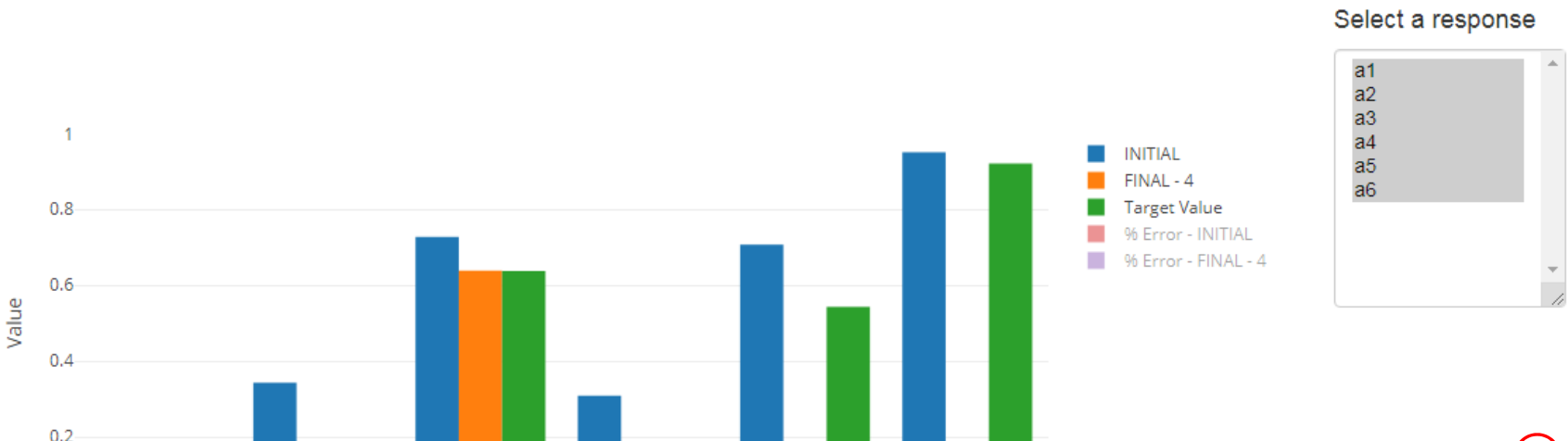
# Review Optimization Results

- 1. Some error values are not reported.
- 2. The error value is dependent on the response values that are reported in the F06 file. Due to design constraint screening, some responses are not reported in the F06 file, so their errors cannot be determined.
- 3. Use the mouse cursor to hover over the message “Not reported in F06\*\*.” More details about the missing response values are displayed. The recommendation is to use the following bulk data entry to report more responses in the F06.

DSCREEN,EQUA,-1000.,100

This is read as follows: “keep normalized constraints greater than a value of -1000. and keep up to 100 normalized constraints.” This will force the optimization procedure to report additional response values to the F06 file.

## Model Matching Bar Charts



Design Cycle	a1	a2	a3	a4	a5
	T3 component(s) of displacement at grid 3 of mode 1	T3 component(s) of displacement at grid 6 of mode 1	T3 component(s) of displacement at grid 9 of mode 1	T1 component(s) of displacement at grid 3 of mode 3	T1 component(s) of displacement at grid 6 of mode 3
INITIAL	6.6205E-02	3.4278E-01	7.2745E-01	3.0902E-01	7.071E-01
FINAL - 4	1.4299E-02	1.7412E-01	6.3826E-01	Not reported in F06**	Not reported in F06**
Target Value	1.4300E-2	1.7410E-1	6.3810E-1	1.2040E-1	5.431E-1
% Error - INITIAL	362.97	96.89	14.00	156.66	30.20
% Error - FINAL - 4	-0.01	0.01	0.03		

2

1

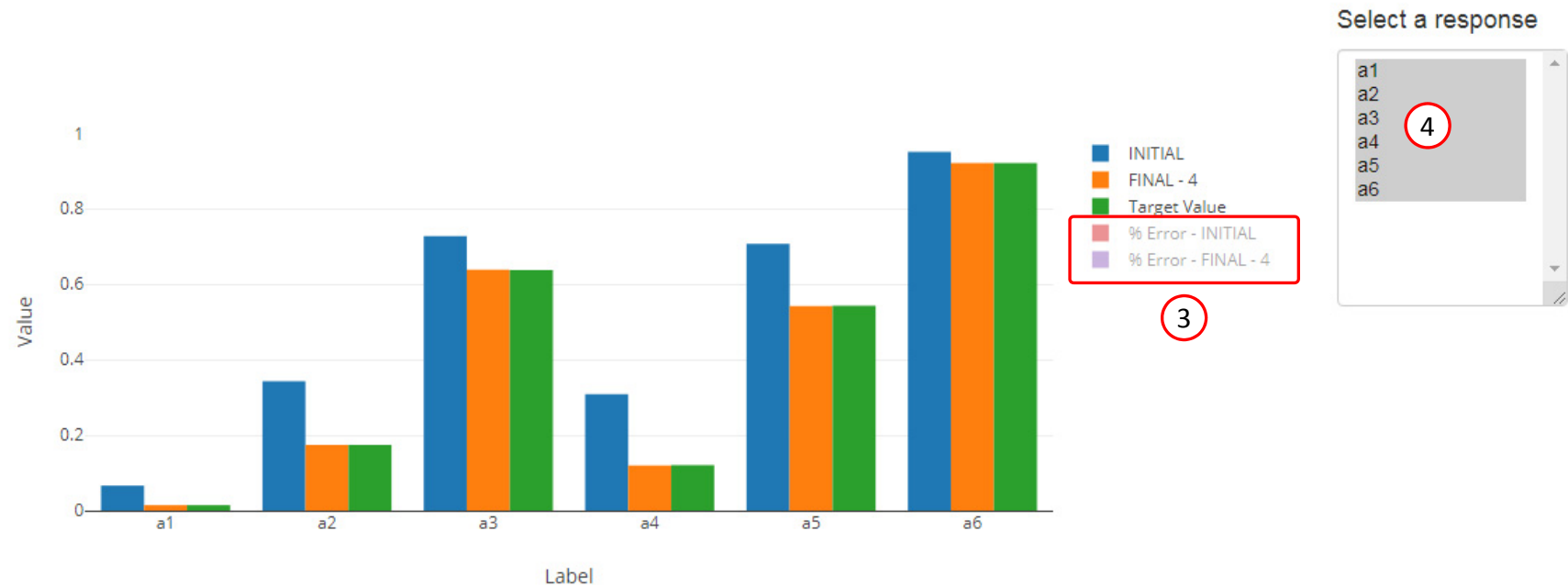
# Review Optimization Results

The optimization is repeated, but with this entry.

DSCREEN,EQUA,-1000.,100

- After the optimization is complete and the results are displayed, note that additional responses are reported and their respective errors are now calculated.
- The change of response a1 is inspected. The initial error was 362.97%, but was reduced to -0.01% during the optimization. Similar results are observed for the other errors. This was a successful model matching.
- Bars for the error values may be displayed by clicking on the indicated entries in the legend.
- Bars for specific responses may be displayed with the indicated select box.

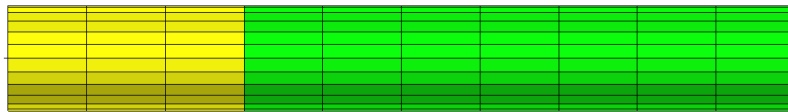
## Model Matching Bar Charts



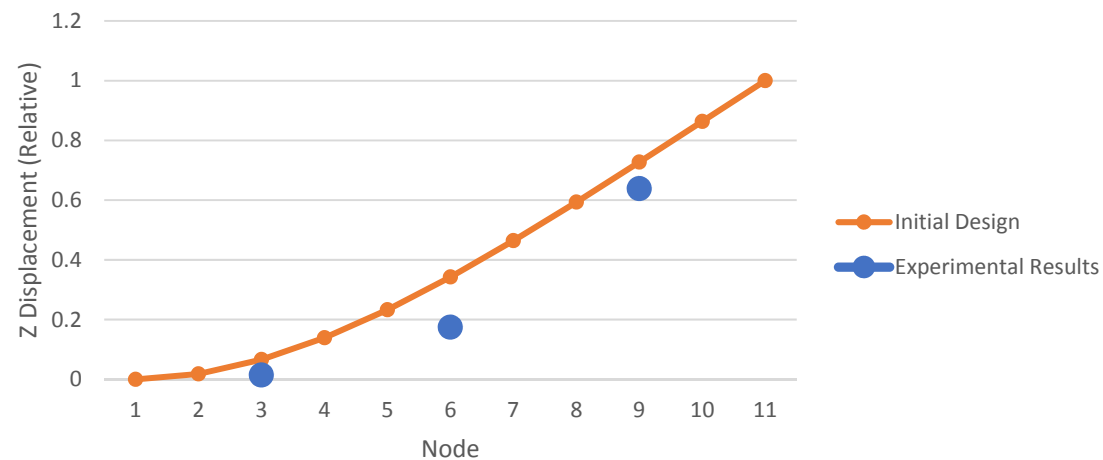
Design Cycle	a1	a2	a3	a4	a5
	T3 component(s) of displacement at grid 3 of mode 1	T3 component(s) of displacement at grid 6 of mode 1	T3 component(s) of displacement at grid 9 of mode 1	T1 component(s) of displacement at grid 3 of mode 3	T1 component(s) of displacement at grid 6 of mode 3
INITIAL	6.6205E-02	3.4278E-01	7.2745E-01	3.0902E-01	7.071
FINAL - 4	1.4299E-02	1.7412E-01	6.3826E-01	1.1993E-01	5.427
Target Value	1.4300E-2	1.7410E-1	6.3810E-1	1.2040E-1	5.431
% Error - INITIAL	362.97	96.89	14.00	156.66	30.20
% Error - FINAL - 4	-0.01	0.01	0.03	-0.39	-0.07

# Results

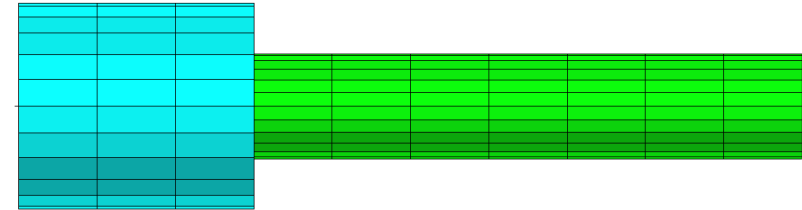
Before Optimization  
Radius: 2 in



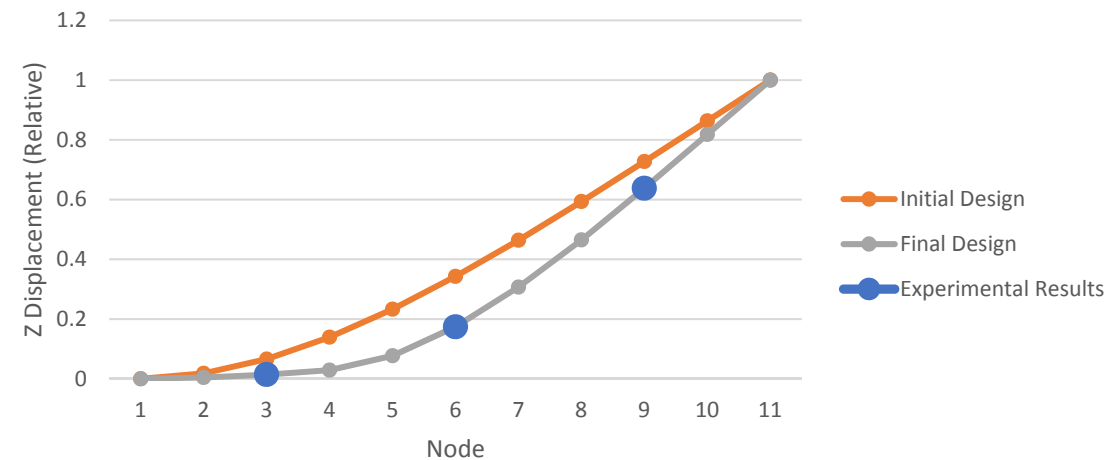
Mode 1 (First Bending Mode)



After Optimization  
◦ Radius 3.93 in



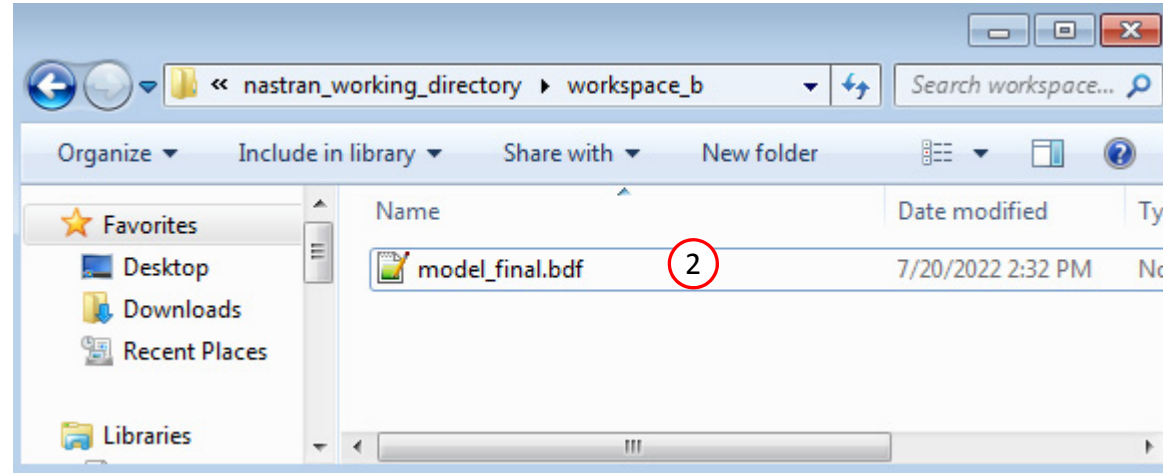
Mode 1 (First Bending Mode)



# Update the Original Model

1. The original input files, e.g. DAT, BDF, etc., contains the original values for the designed properties. These original values must be updated to use the new and optimized values.
2. A new BDF file has been created in `nastran_working_directory/workspace_b/model_final.bdf`.
3. The file `model_final.bdf` is a copy of the original input files but the original values for the designed properties have been updated to use the optimized values.

- If you were using multiple INCLUDE files, `model_final.bdf` is a combination of all INCLUDE files. The next few slides discuss an alternative method of using the PCH to BDF web app to update the values for the designed properties while preserving separate INCLUDE files.



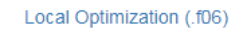
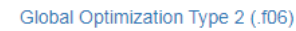
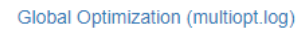
## Original Input Files

```
$ Elements and Element Properties for region : Section_1
PBARL 1 1 ROD
2.
$ Elements and Element Properties for region : Section_2
PBARL 2 1 ROD
2.
```

## Updated BDF File (model\_final.bdf)

```
$ Elements and Element Properties for region : Section_1
PBARL 1 1MSCBML0 ROD
3.93164 0.0
$ Elements and Element Properties for region : Section_2
PBARL 2 1 ROD
2.
```

1. Click Results
2. Click PCH to BDF



## Converter

### PCH to BDF

# Update the Original Model

The original .bdf/.dat file has old information about the properties. The properties will be updated.

1. Select the model.pch file
2. Select the original file: degvtn01.dat
3. A summary of updates that will be performed are shown
4. Click Download and a new updated BDF file is downloaded

## Step 1 - Select PCH File

model.pch **1**

Inspecting: 100%

☐ List of Selected Files

### PCH Entries

PBARL	1	1MSCBML0	ROD
	3.93164	0.0	

## Step 2 - Select BDF Files

degvtn01.dat **2**

Inspecting: 100%

☐ List of Selected Files

### BDF Entries

PBARL	1	1	ROD
	2.		



## Step 3 - Download New BDF Files

On download, the PCH entries will replace older BDF entries.

**4**

# Update the Original Model

1. Note the entries have been updated with the optimized properties

degvtn01.dat	degvtn01.dat
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
32	32
33	33
34	34
35	35
36	36
37	37
38	38
39	39
40	40
41	41
42	42
43	43
44	44
45	45
46	46
47	47
48	48
49	49
50	50
51	51
52	52
53	53
54	54
55	55
56	56
57	57
58	58
59	59
60	60
61	61
62	62
63	63
64	64
65	65
66	66

Original BDF/DAT File

Downloaded BDF/DAT File

# Inspection of MSC Nastran Results with the Post-processor Web App

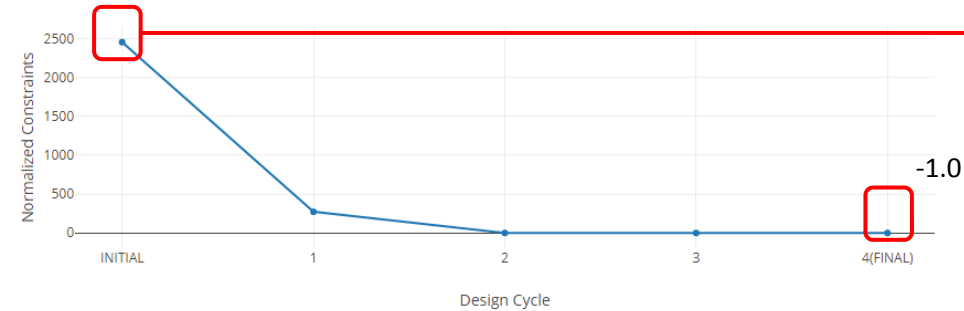
---

# Normalized Constraints

- All constraints are normalized. For each design cycle, the maximum normalized constraint (NC) is reported in the Normalized Constraints plot.
- The Responses web app is used to inspect the corresponding response for each maximum normalized constraint value.
  - For the initial design, the maximum NC is 2453.2 and corresponds to error value 2.4542. This was response R1 defined by a DRESP2 and DEQATN entry.
  - For the final design, the maximum NC is -1.0 but no responses are listed in the table. This is because the DSCREEN entry's TRS field has a default value of -0.5. Any NCs below this value are not reported in the F06 file and are not listed in the table.

## Normalized Constraints

+ Info



## SOL 200 Web App - Responses

Home

## Responses

<span>Reset view</span> <span>Violated constraints</span> <span>Active constraints</span> <span>Maximum constraint for each design cycle</span>												
Design Cycle	Subcase	Label	Response Type	Normalized Constraint	Lower Bound	Value	Upper Bound	Normalized Constraint	Show More Information	designCycleNumber	DRESP2 ID	EQUATION ID
INITIAL	1001	R1	RETAINED DRESP2		N/A	2.4542E+00	1.0000E-03 V	2.4532E+03**		0	9000001	170001
1	1001	R1	RETAINED DRESP2		N/A	2.7253E-01	1.0000E-03 V	2.7153E+02**		1	9000001	170001

# Post-processor Web App

- For response R1, the eigenvector values for mode 1 were used. Note the values for responses a1, a2 and a3.
- The Post-processor web app is used to confirm the eigenvector values.

## Responses

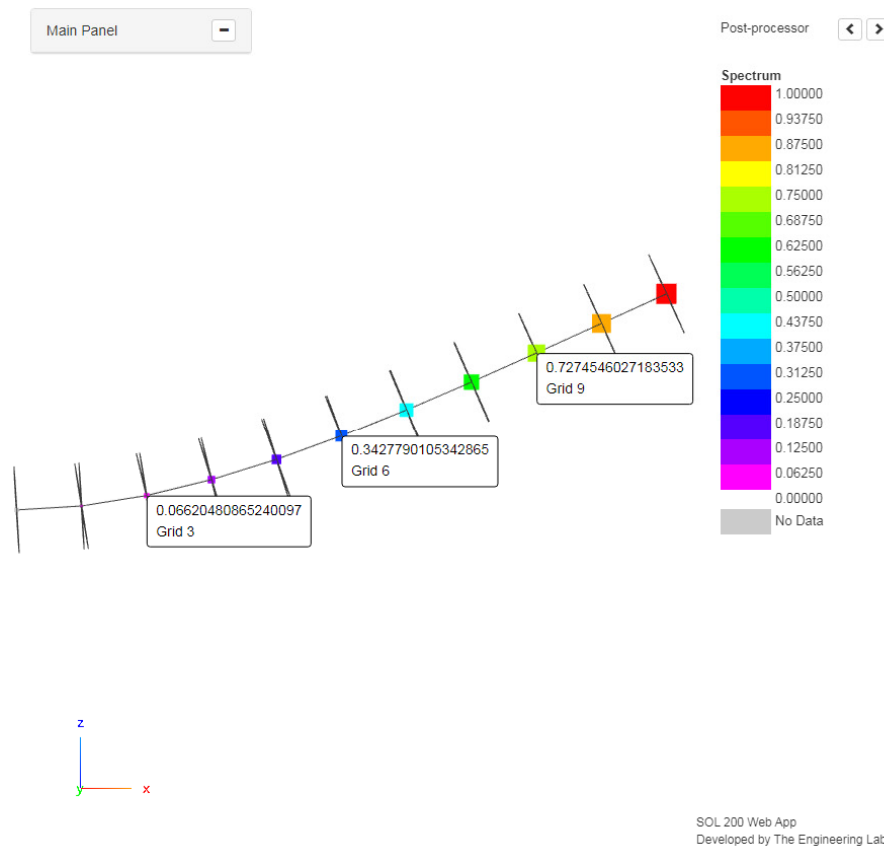
Reset view Violated constraints Active constraints Maximum constraint for each design cycle													
Design Cycle	Subcase	Label	Response Type	Normalized Constraint	Lower Bound	Value	Upper Bound	Normalized Constraint	Show More Information	designCycleNumber	GRID ID	COMPONENT NO.	MODE
Search	Search	a	Search	Search	Se	Search	Se	Search					
INITIAL	1001	a1	EIGENVECTOR DISPLACEMENT		N/A	6.6205E-02	N/A			0	3	3	1
INITIAL	1001	a2	EIGENVECTOR DISPLACEMENT		N/A	3.4278E-01	N/A			0	6	3	1
INITIAL	1001	a3	EIGENVECTOR DISPLACEMENT		N/A	7.2745E-01	N/A			0	9	3	1
INITIAL	1001	a4	EIGENVECTOR DISPLACEMENT		N/A	3.0902E-01	N/A			0	3	1	3
INITIAL	1001	a5	EIGENVECTOR DISPLACEMENT		N/A	7.0711E-01	N/A			0	6	1	3
INITIAL	1001	a6	EIGENVECTOR DISPLACEMENT		N/A	9.5106E-01	N/A			0	9	1	3
1	1001	a1	EIGENVECTOR DISPLACEMENT		N/A	3.1642E-02	N/A			1		3	1
1	1001	a2	EIGENVECTOR DISPLACEMENT		N/A	2.2991E-01	N/A			1		3	1
1	1001	a3	EIGENVECTOR DISPLACEMENT		N/A	6.6797E-01	N/A			1		3	1
1	1001	a4	EIGENVECTOR DISPLACEMENT		N/A	1.8325E-01	N/A			1		1	3
1	1001	a5	EIGENVECTOR DISPLACEMENT		N/A	5.9866E-01	N/A			1		1	3
2	1001	a1	EIGENVECTOR DISPLACEMENT		N/A	1.4086E-02	N/A			2		3	1
2	1001	a2	EIGENVECTOR DISPLACEMENT		N/A	1.7343E-01	N/A			2		3	1
2	1001	a3	EIGENVECTOR DISPLACEMENT		N/A	6.3789E-01	N/A			2		3	1
FINAL - 4(FI	1001	a1	EIGENVECTOR DISPLACEMENT		N/A	1.4299E-02	N/A			4	3	3	1
FINAL - 4(FI	1001	a2	EIGENVECTOR DISPLACEMENT		N/A	1.7412E-01	N/A			4	6	3	1
FINAL - 4(FI	1001	a3	EIGENVECTOR DISPLACEMENT		N/A	6.3826E-01	N/A			4	9	3	1

# Post-processor Web App

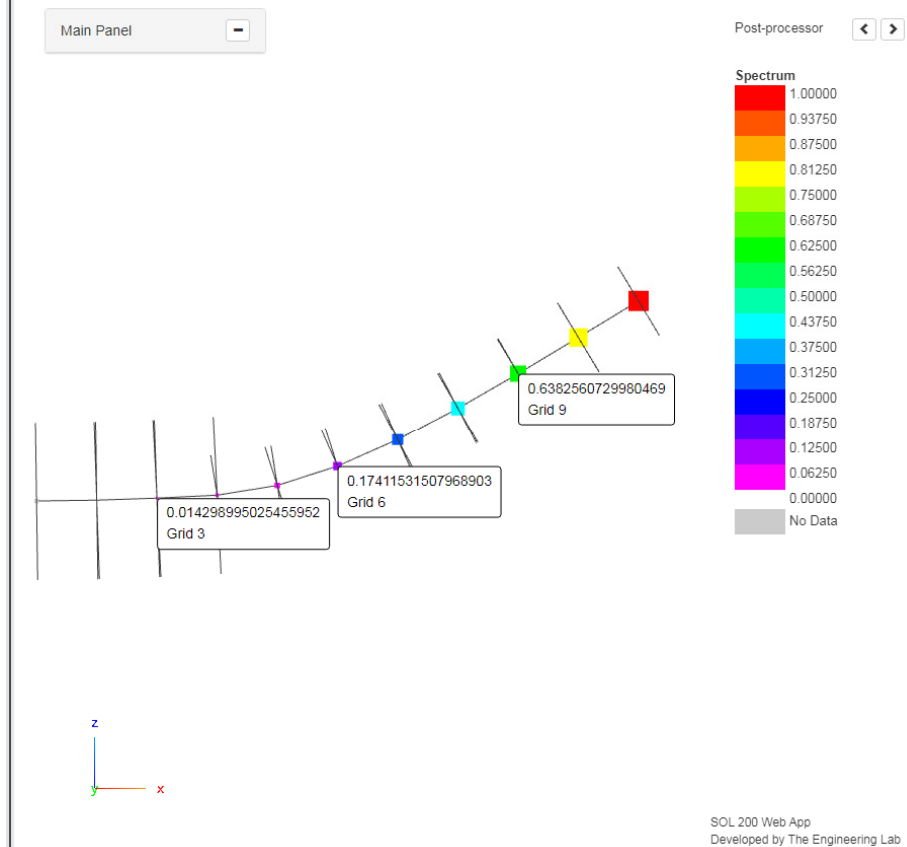
- The Post-processor web app is used to inspect the MSC Nastran results.
- Consider mode 1.
  - For the initial design, the z-component of the eigenvector for grid 3, 6 and 9 correspond to .066, .343 and .727.
  - For the final design, the z-component of the eigenvector for grid 3, 6 and 9 correspond to .014, .174, .638.

- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

## Eigenvector for Mode 1



Initial Design



Final Design

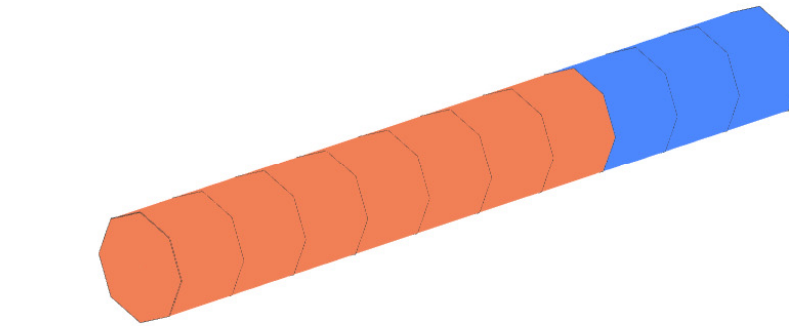
# Post-processor Web App

- The cross section of the CBAR elements of the initial and final design are compared.

- Refer to the Post-processor web app tutorials to learn more about MSC Nastran results.

## Cross section of CBAR elements

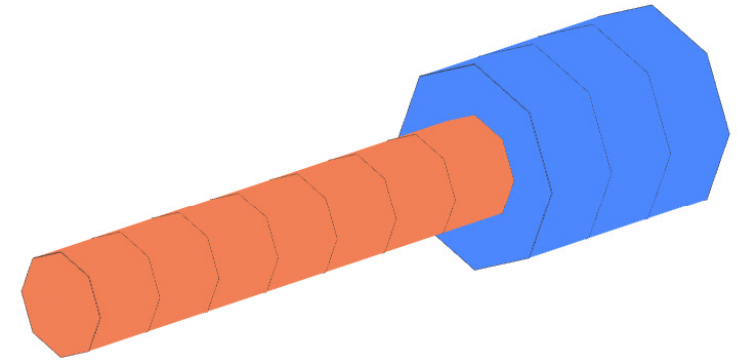
Main Panel



SOL 200 Web App  
Developed by The Engineering Lab

Initial Design

Main Panel



SOL 200 Web App  
Developed by The Engineering Lab

Final Design

End of Tutorial

# Appendix

---

# Appendix Contents

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- Frequently Asked Questions
  - After performing the example, the solution is different from the tutorial. What happened?

# Frequently Asked Questions

## Question:

- After performing the example, the solution is different from the tutorial. What happened?

## Answer:

- Remember to enable **Mode Tracking**
- See directions to the right

1

```
new1.txt
8 SOL 200
9 CEND
10
11 $
12 TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
13 SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
14 $
15 $ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
16 $ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
17 $ COMPUTED MODES AND ACTUAL MODES
18 $
19 $
20 SPC = 1
21 $
22 DESOBJ(MIN) = 9000000
23 $ DESGLB Slot
24 $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
25 SUBCASE 1001
26 ANALYSIS = MODES
27 DESSUB = 40001001
28 $ DESRAN Slot
29
30 DISP = ALL
31 METHOD = 1
32 $
33 BEGIN BULK
34
35 INCLUDE './design_model.bdf'
36
37
38 PARAM, SPARSEDR, NO
39 PARAM GRDPNT 0

model.bdf
8 SOL 200
9 CEND
10
11 $
12 TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
13 SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
14 $
15 $ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
16 $ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
17 $ COMPUTED MODES AND ACTUAL MODES
18 $
19 $
20 SPC = 1
21 $
22 DESOBJ(MIN) = 9000000
23 $ DESGLB Slot
24 $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
25 SUBCASE 1001
26 ANALYSIS = MODES
27 DESSUB = 40001001
28 $ DESRAN Slot
29 modtrak = 800
30 DISP = ALL
31 METHOD = 1
32 $
33 BEGIN BULK
34
35 INCLUDE './design_model.bdf'
36 modtrak, 800, 1, 100
37
38 PARAM, SPARSEDR, NO
39 PARAM GRDPNT 0
```