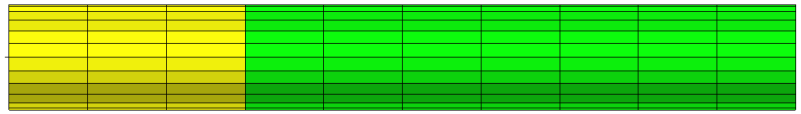
Workshop - Model Matching / System Identification

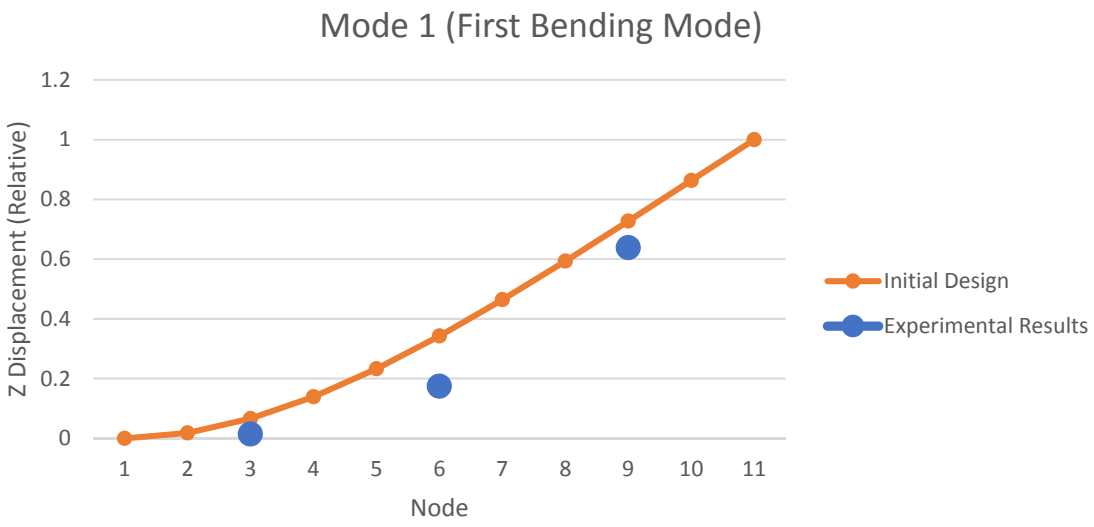
AN MSC NASTRAN SOL 200 TUTORIAL

Questions? Email: christian@ the-engineering-lab.com

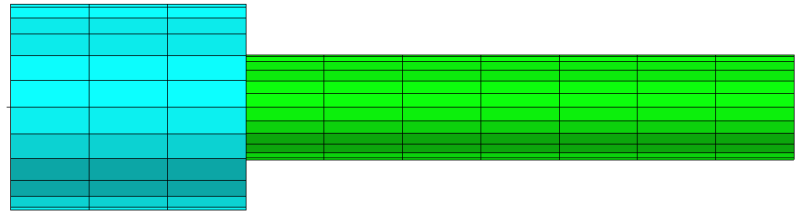
Goal: Use optimization correlate test data and analysis results

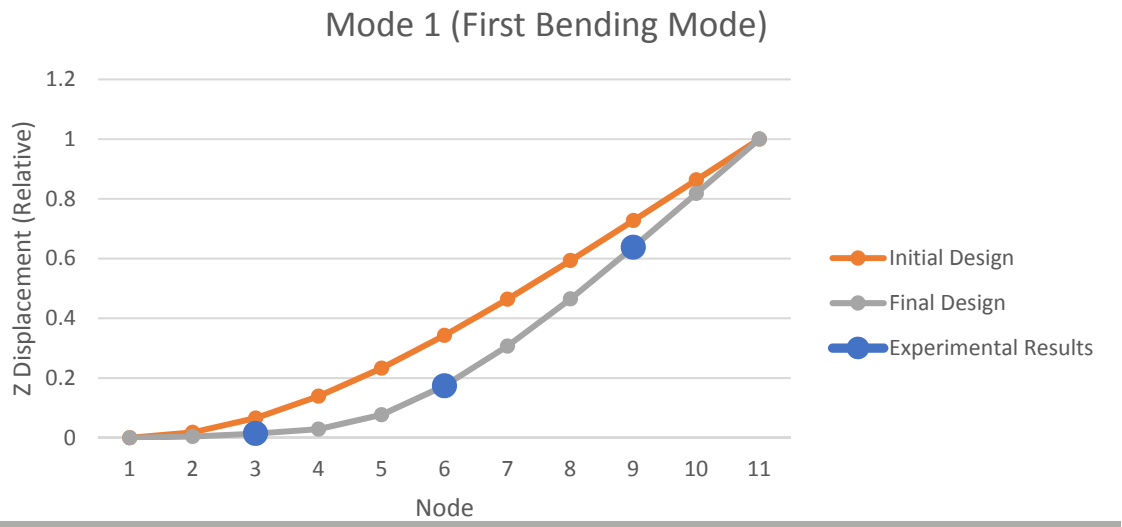
Before Optimization
Radius: 2 in





After Optimization
- Radius 3.93 in





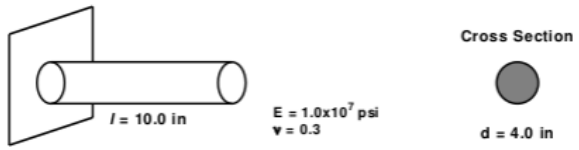
Details of the structural model

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

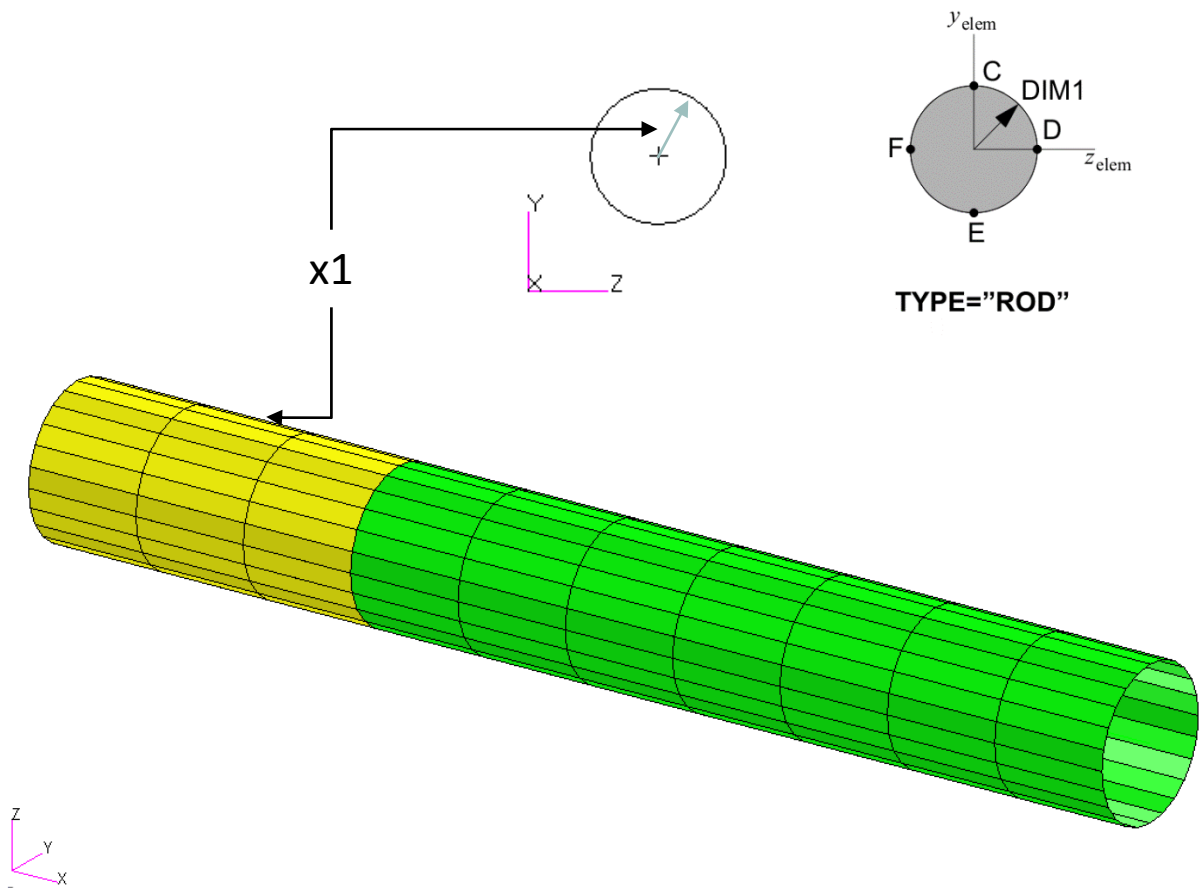
Figure 25-13. SYSTEM ID — SIMPLE BEAM MODEL



BAR 1 A	BAR 2 A	BAR 3 A	BAR 4	BAR 5	BAR 6	BAR 7	BAR 8	BAR 9	BAR 10

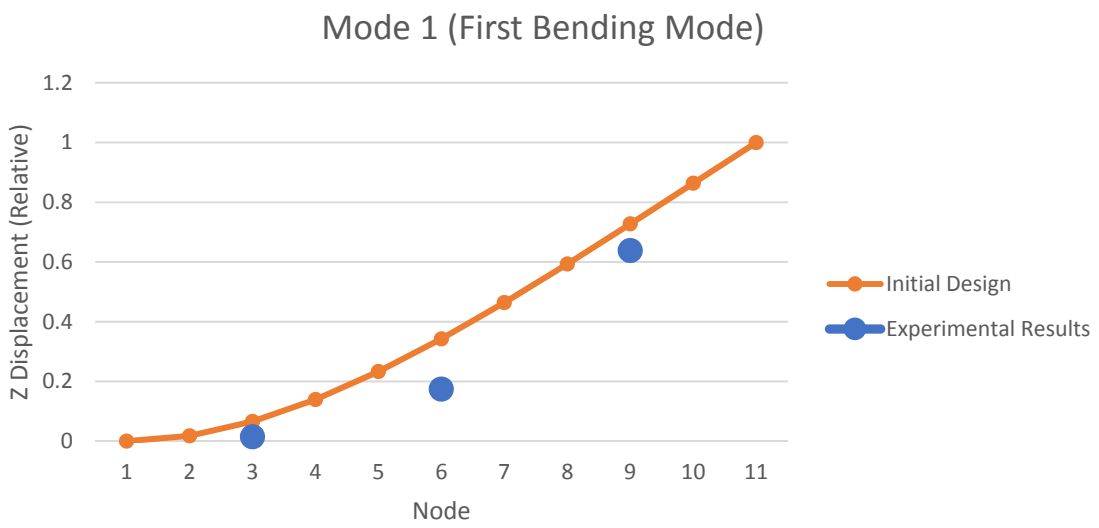
25-72 MULTIDISCIPLINARY DESIGN OPTIMIZATION **UAI/*NASTRAN***

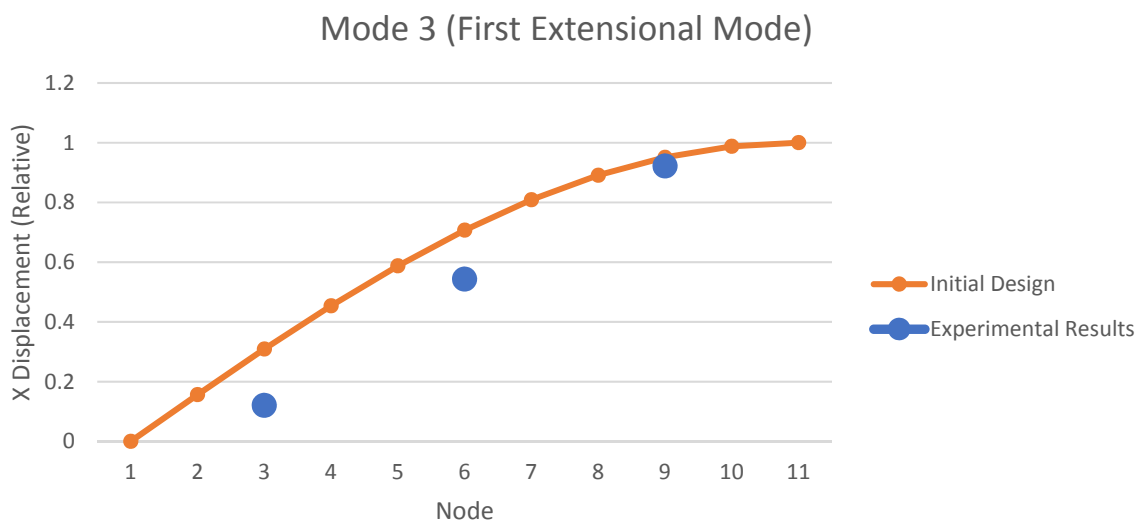
UAI/NASTRAN User's Guide for Version 20.1
Chapter 25 - MULTIDISCIPLINARY DESIGN OPTIMIZATION -
25.6.6 System Identification



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



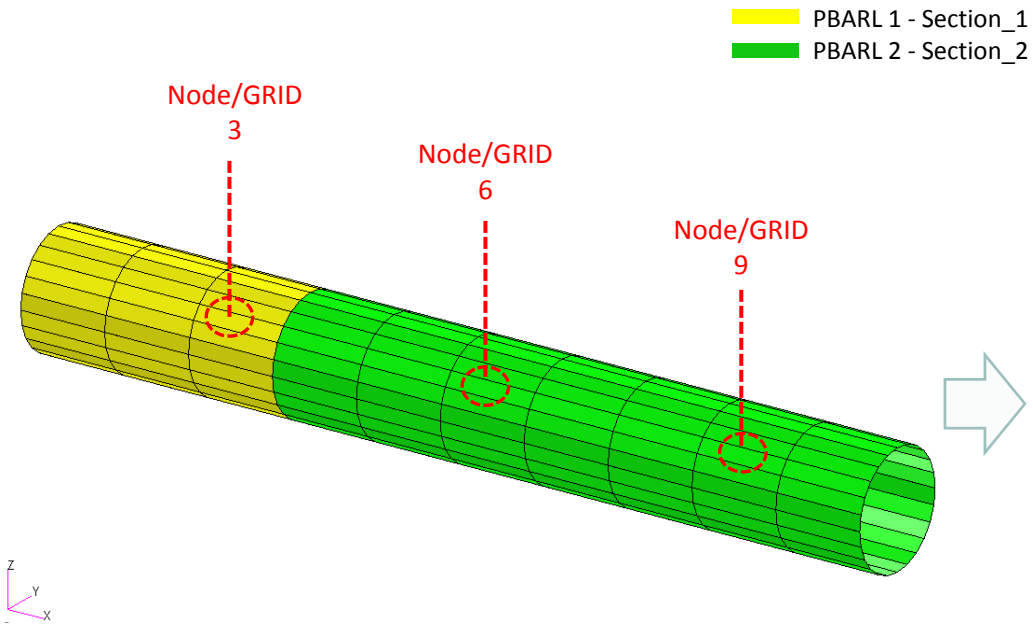


Optimization Problem Statement

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: 3rd component of relative displacement for mode 1 at grid 3
- a2: 3rd component of relative displacement for mode 1 at grid 6
- a3: 3rd component of relative displacement for mode 1 at grid 9

Design Constraints, Equation

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

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

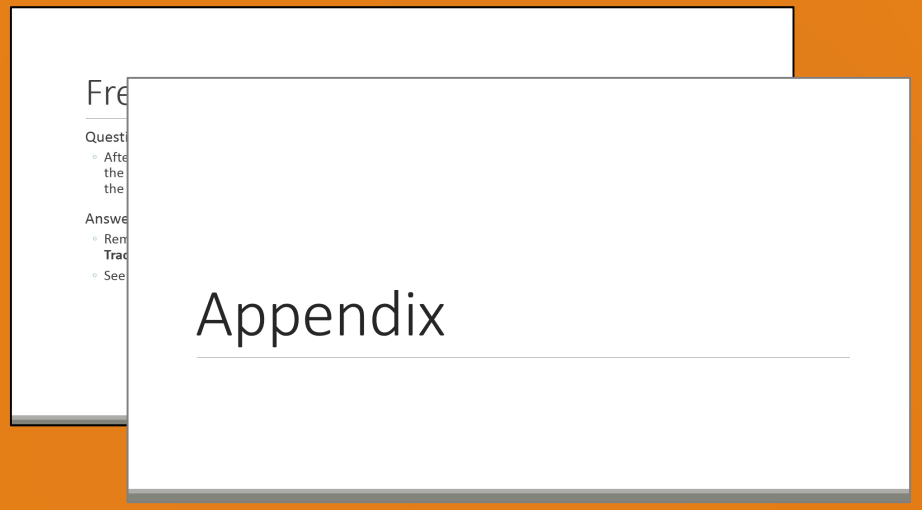
$R3 = \left(\frac{a6-.9216}{.9216}\right)^2$ R3 < .001

- a4: 1st component of relative displacement for mode 3 at grid 3
- a5: 1st component of relative displacement for mode 3 at grid 6
- a6: 1st 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

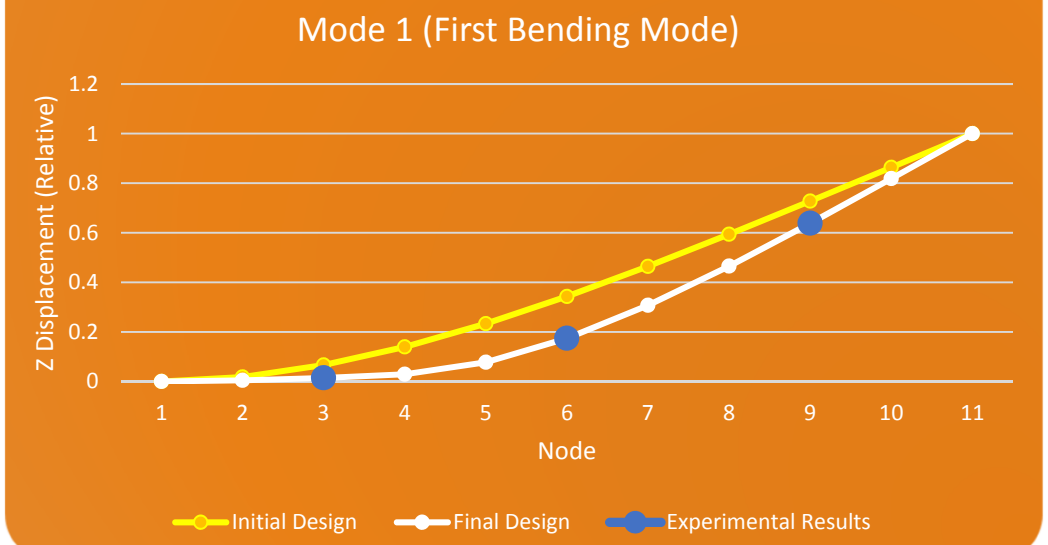
Tutorial

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.

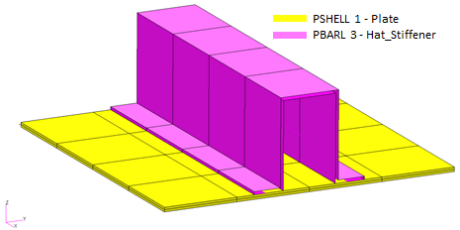
Compatibility

- 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.

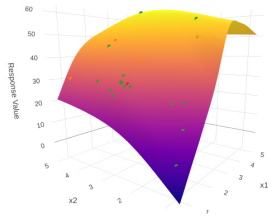
Benefits

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

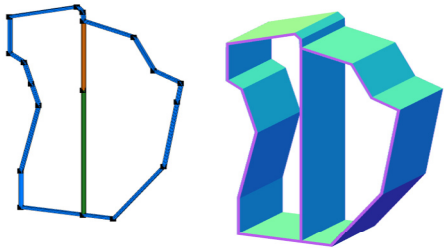
Web Apps



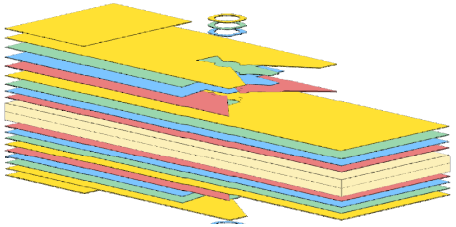
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



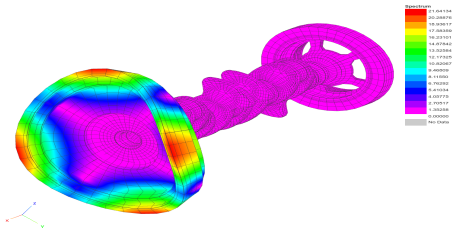
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



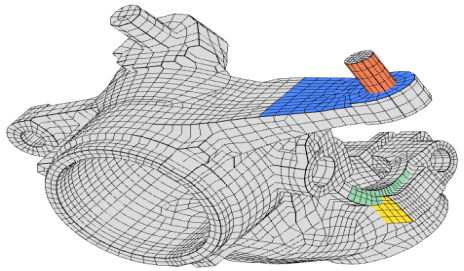
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



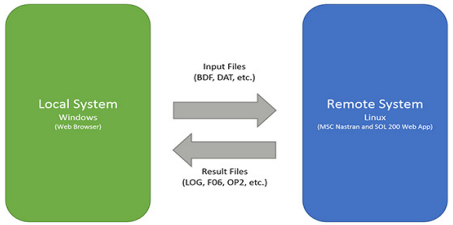
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



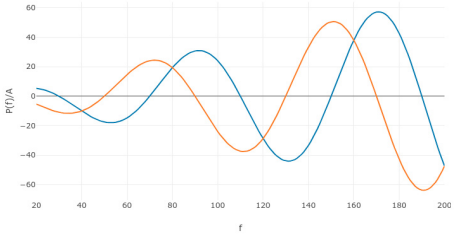
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



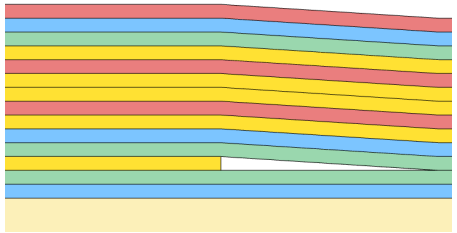
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



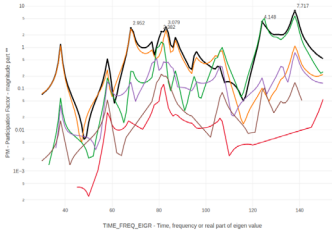
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



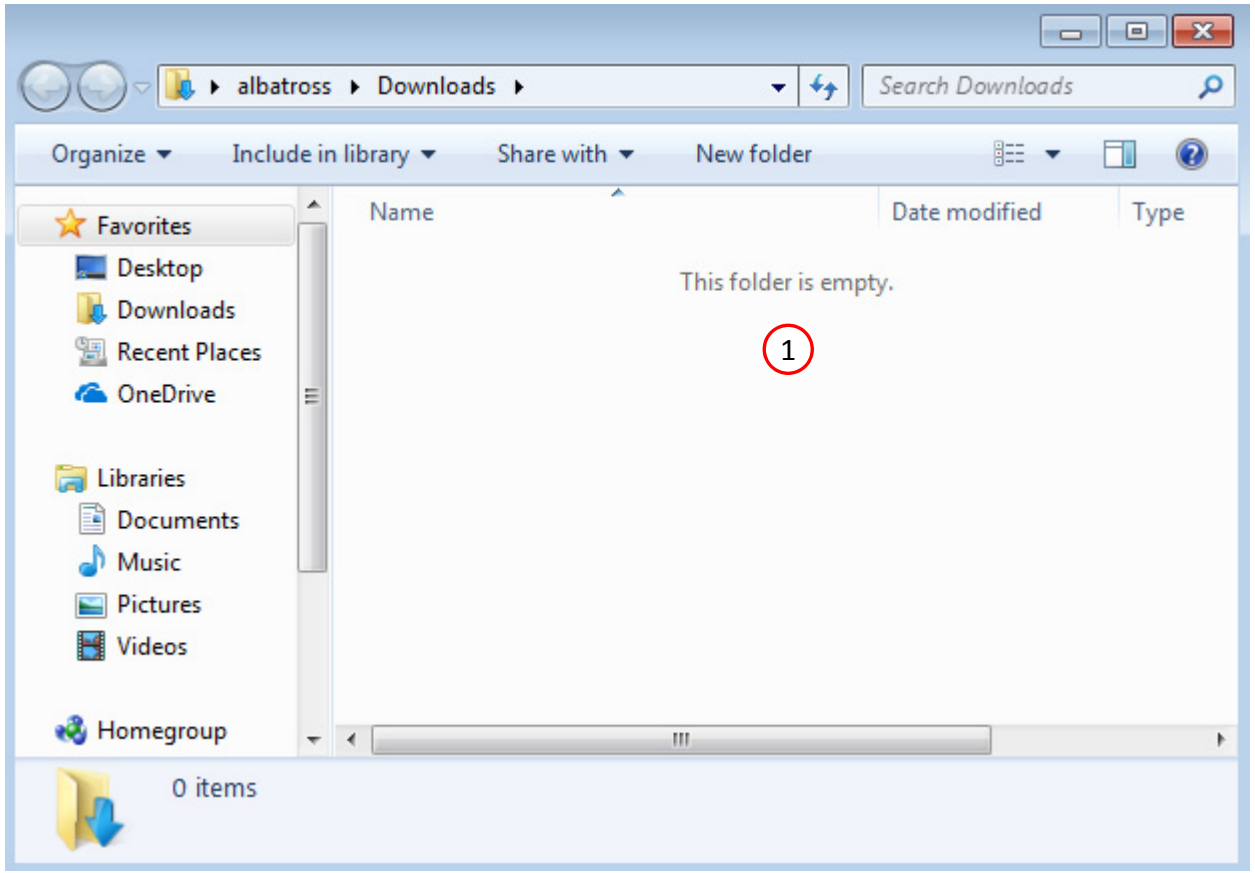
Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies



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

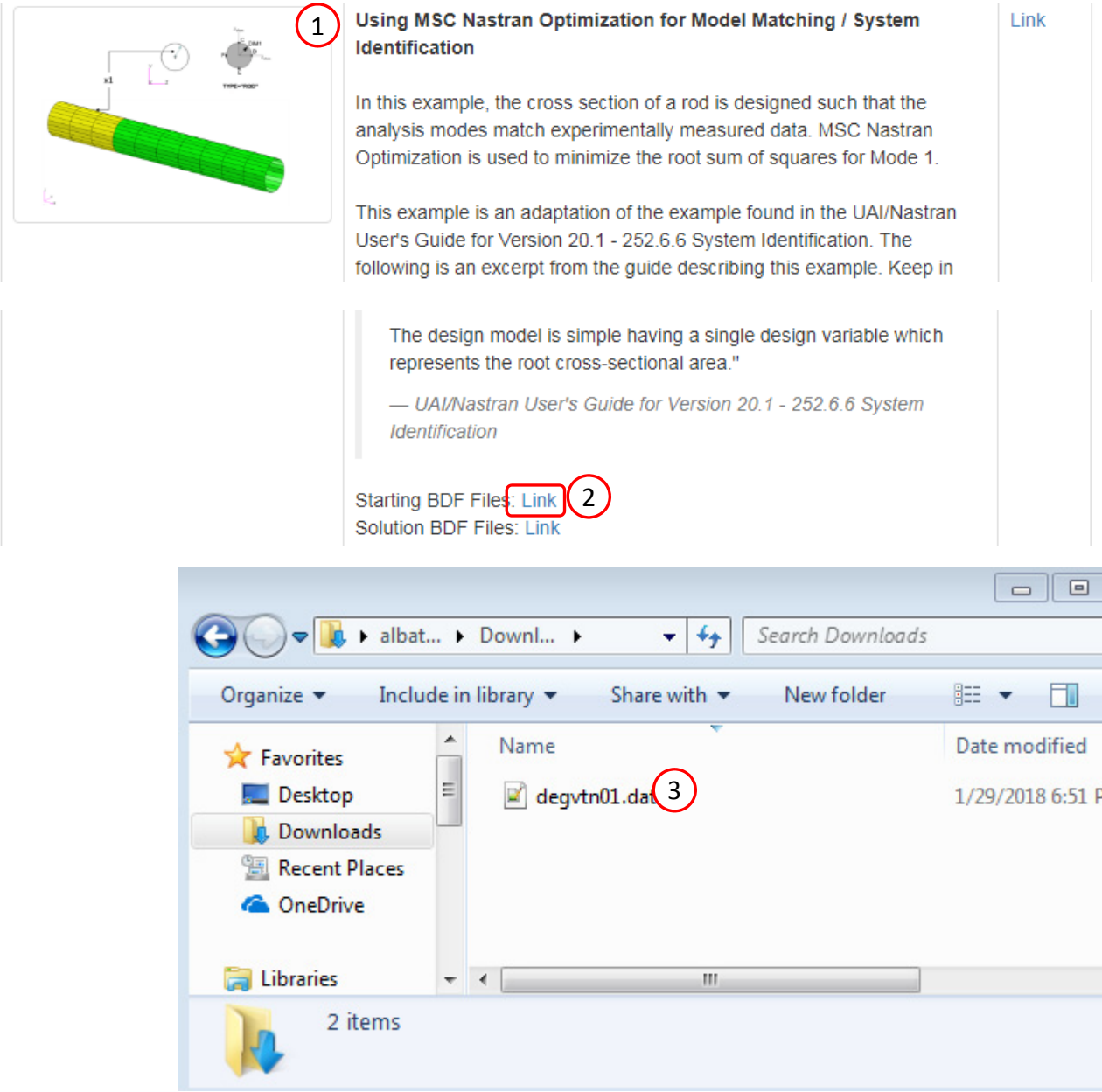
1. Click on the indicated link

- 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.



Open the Correct Page

1. Click on the indicated link

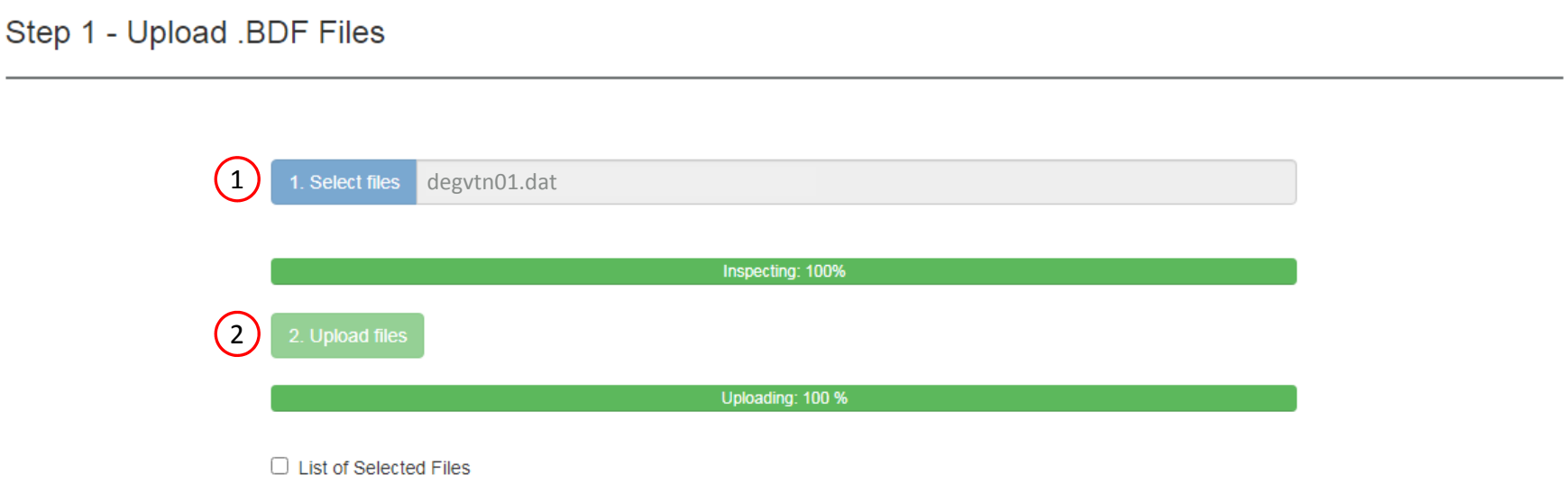
- MSC Nastran can perform many optimization types. The SOL 200 Web App includes dedicated web apps for the following:
  - Optimization for SOL 200 (Size, Topology, Topometry, Topography, Local Optimization, Sensitivity Analysis and Global Optimization)
  - Multi Model Optimization
  - Machine Learning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

The Engineering Lab

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.



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 (1)	Search	Search	Search	Search
(2) +	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

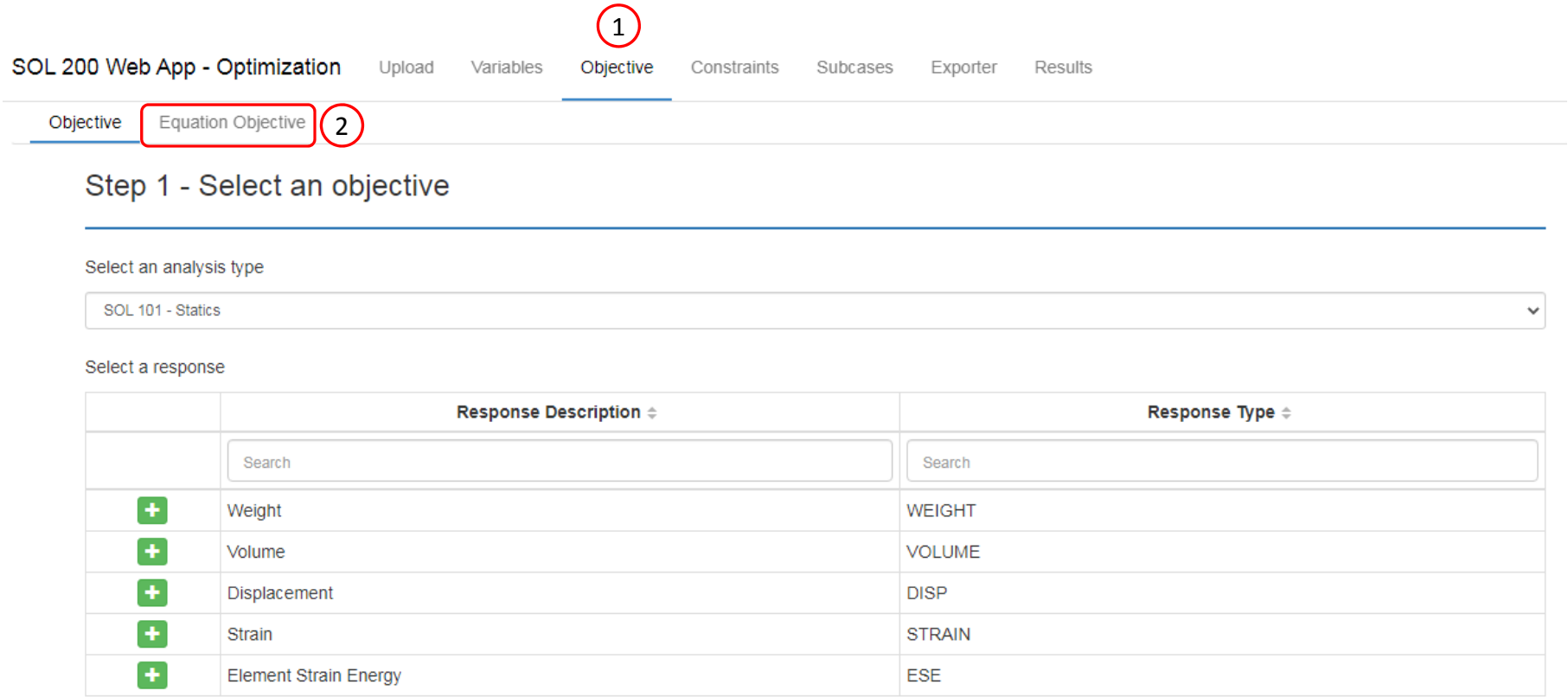
+ Options

	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 (3)	10. (4)	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.”



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	Sear	Search	Search	Search	Search	Search
✖	a1	✔	DISP		3 - T3 (Rectangular z, Cylindrical z	1	3
✖	a2	✔	DISP	3	3 - T3 (Rectangular z, Cylindrical z	1	6
✖	a3	✔	DISP		3 - T3 (Rectangular z, Cylindrical z	1	9

Create Responses

1. Click 3 times on the Displacement response to create responses: a4, a5 and a6
2. Click 10 on the pagination bar
3. 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
	Search	Search
+	Weight	WEIGHT
+	Volume	VOLUME
+	Eigenvalue	EIGN
+	Frequency	FREQ
1 +	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	Sear	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
	a4		DISP		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

3

5 10 20 30 40 50

2

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 (1) | Other | User's Guide | Home

Step 1 - Configure model matching

+ Options

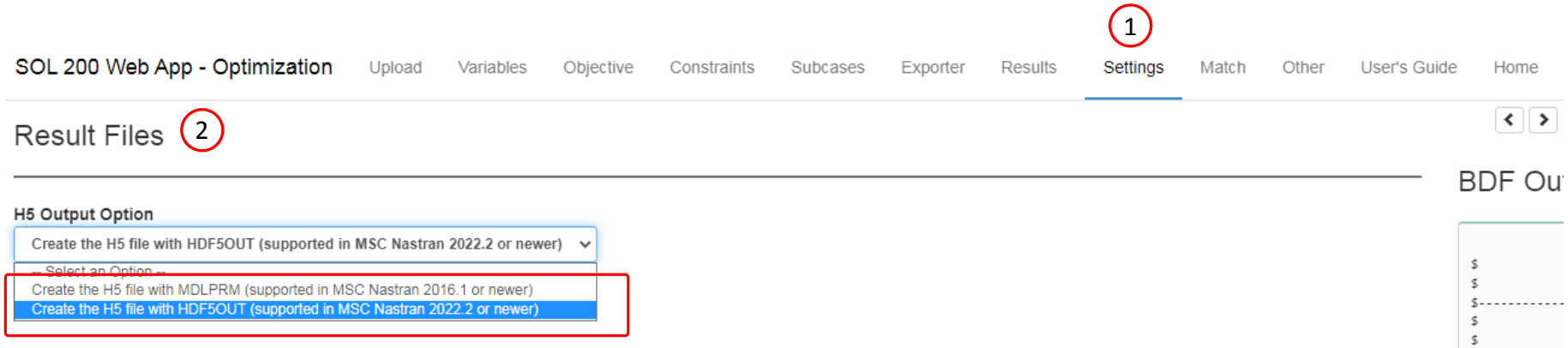
Status	Label	Single Scalar?	Description	Target Value	Include in Objective	Max Allowed Error
Search	Search	Search	Search	Search	Search (3)	Search (4)
	a1	Yes	T3 component(s) of displacement at grid 3 of mode 1	.0143	☑	Example: -100.1
	a2	Yes	T3 component(s) of displacement at grid 6 of mode 1	.1741	☑	Example: -100.1
	a3	Yes	T3 component(s) of displacement at grid 9 of mode 1	.6381	☑	Example: -100.1
	a4	Yes	T1 component(s) of displacement at grid 3 of mode 3	.1204	☐	.001
	a5	Yes	T1 component(s) of displacement at grid 6 of mode 3	.5431	☐	.001
	a6	Yes	T1 component(s) of displacement at grid 9 of mode 3	.9216	☐	.001

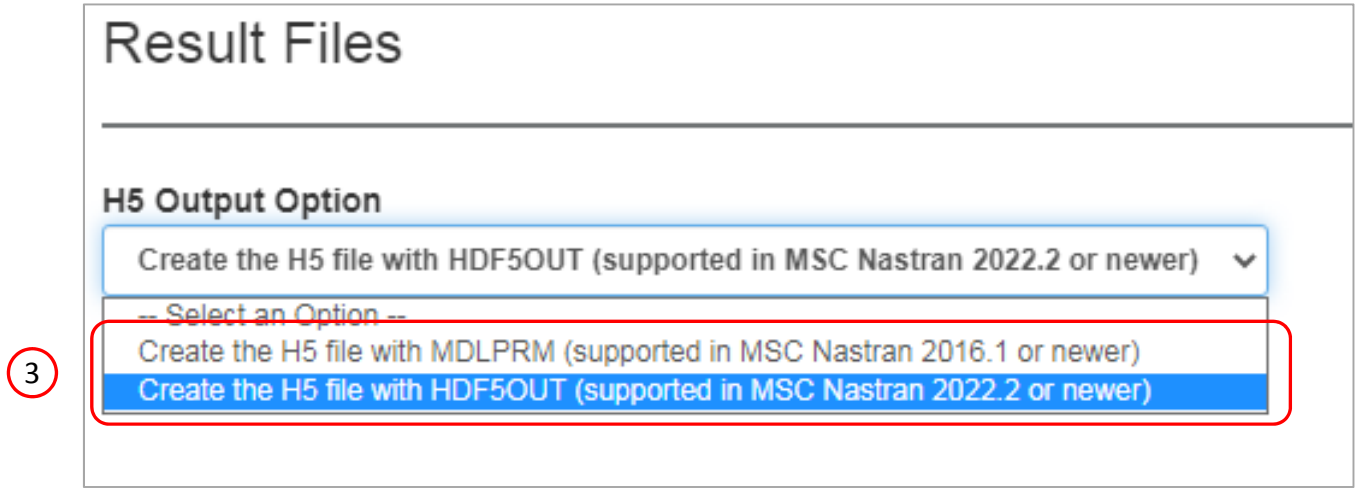
(2) (5)

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.

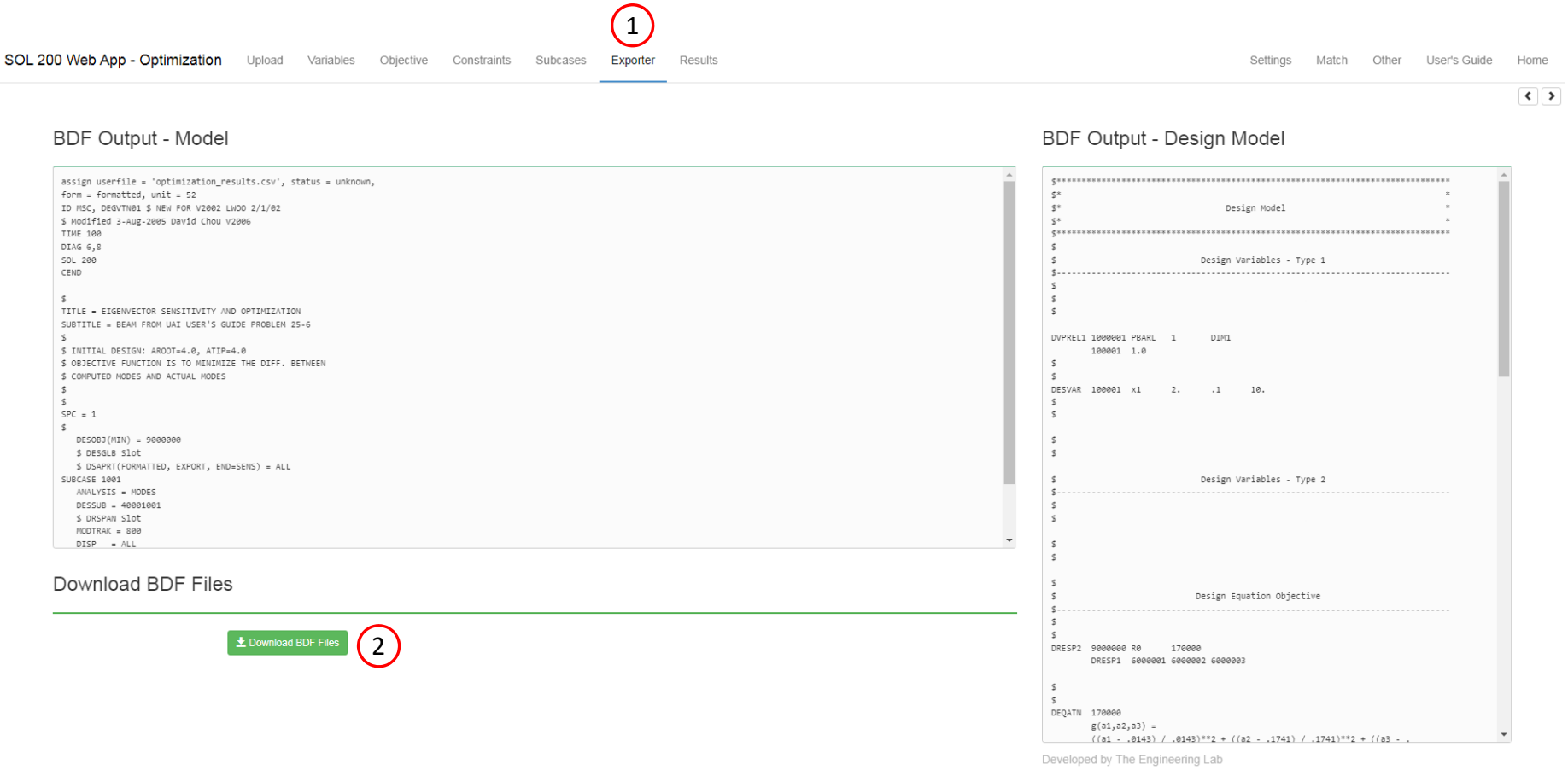




Export New BDF Files

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

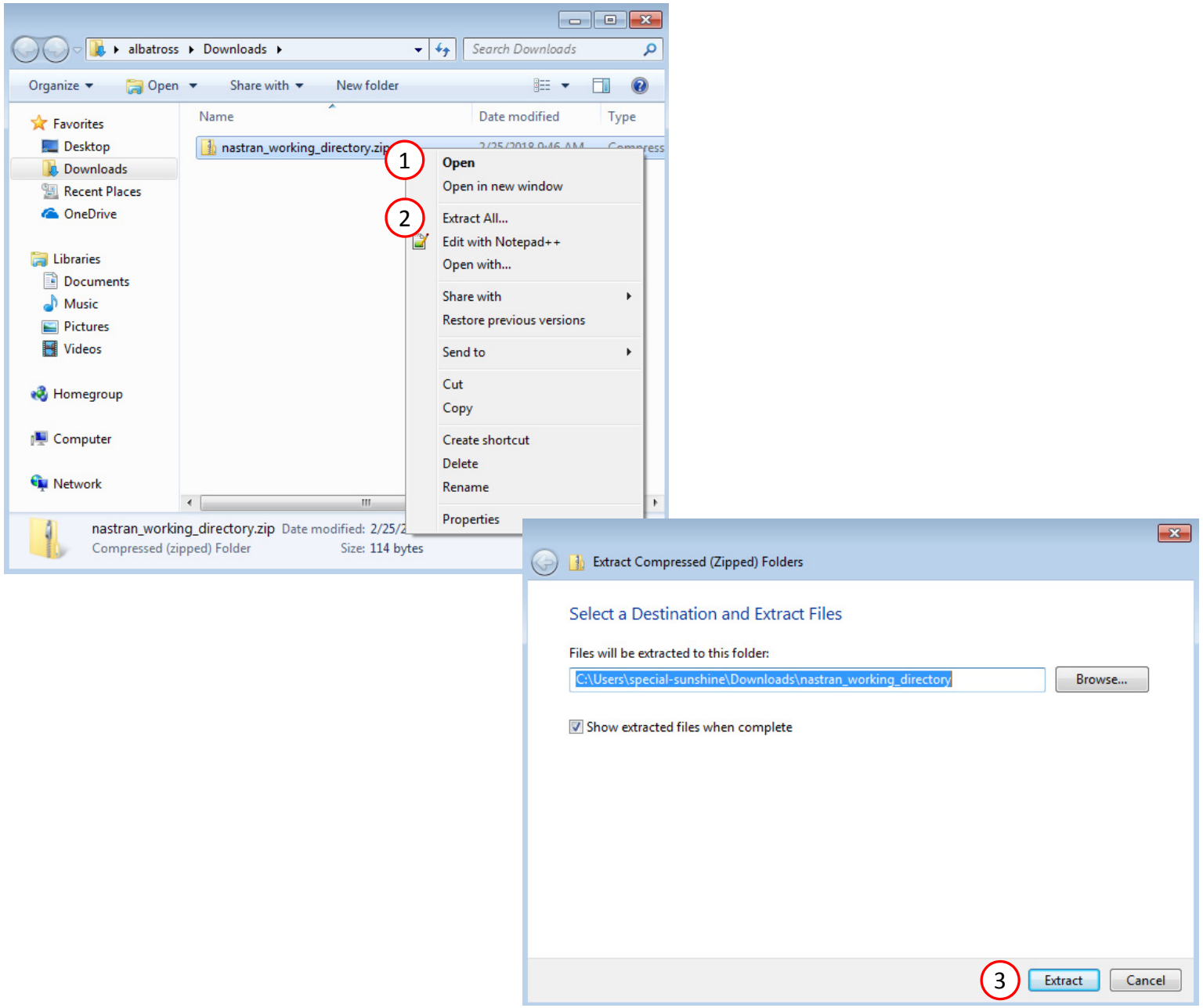
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



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_degvtn01\2_solution_files\design_model.bdf - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

model.bdf

```
assign userfile = 'optimization_results.csv', status
form = formatted, unit = 52
ID MSC, DEGVTN01 $ NEW FOR V2002 LWOO 2/1/02
$ Modified 3-Aug-2005 David Chou v2006
TIME 100
DIAG 6,8
SOL 200
CEND

$
TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
$
$ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
$ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
$ COMPUTED MODES AND ACTUAL MODES
$
$
SPC = 1
$
   DESOBJ(MIN) = 9000000
   $ DESGLB Slot
   $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1001
   ANALYSIS = MODES
   DESSUB = 40001001
   $ DRSPAN Slot
   MODTRAK = 800
   DISP    = ALL
   METHOD = 1
$
BEGIN BULK
INCLUDE './design_model.bdf'
```

2

design_model.bdf

```
$                                   Constraint Groups
$   1   ||   2   ||   3   ||   4   ||   5   ||   6   ||   7
$DCONADD DCID    DC1      DC2      DC3      etc.
DCONADD 40001001 50000015000002 5000003


$
$                          Optimization Control Setti
$-----------------------------------------------------
$   1   ||   2   ||   3   ||   4   ||   5   ||   6   ||   7
$DOPTPRM PARAM1 VAL1     PARAM2   VAL2     PARAM3   VAL3

DOPTPRM DESMAX  20       P1       1        P2       15



$
$ Parameter that supports output of CSV
PARAM   XYUNIT  52
$ Parameter that supports punch file (.pch) output
PARAM   DESPCH1 -1

$ The following line is exactly 80 columns
$   1   ||   2   ||   3   ||   4   ||   5   ||   6   ||   7

$ Mode Tracking Parameter
MODTRAK 800      1        100      .9


$ urlUsed: http://localhost:8080/optimization/
$ Use Match: 6000001, 6000002, 6000003, 6000004, 6000
$LCOMM  x1       DIM1, ROD - Radius, of PBARL 1 (Secti
```

3

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

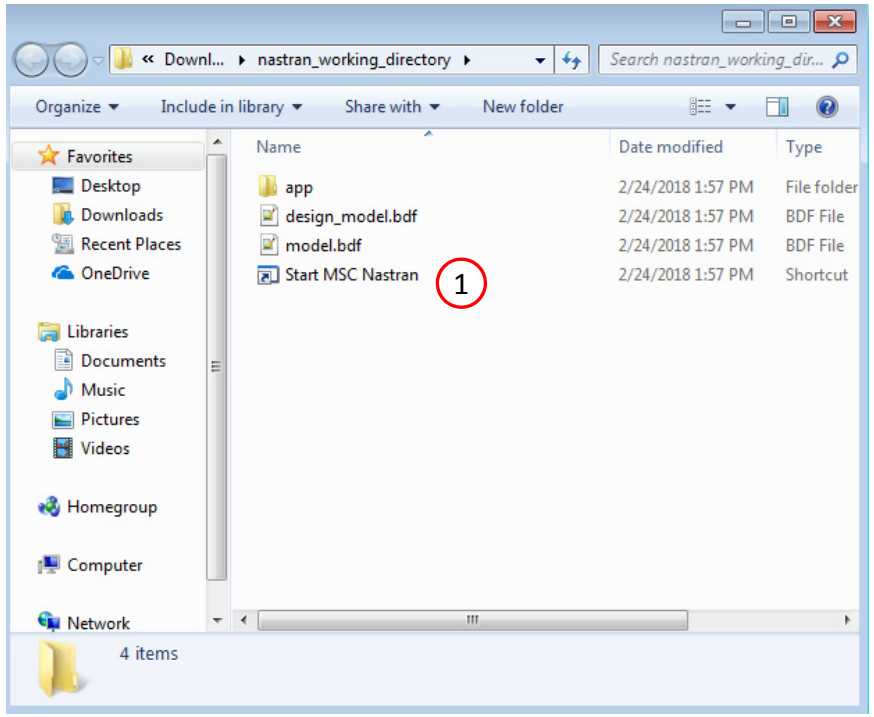
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the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

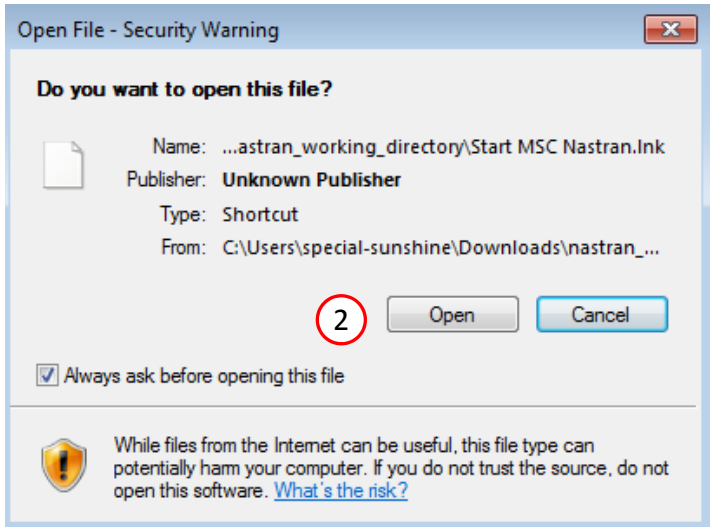
Using Linux?

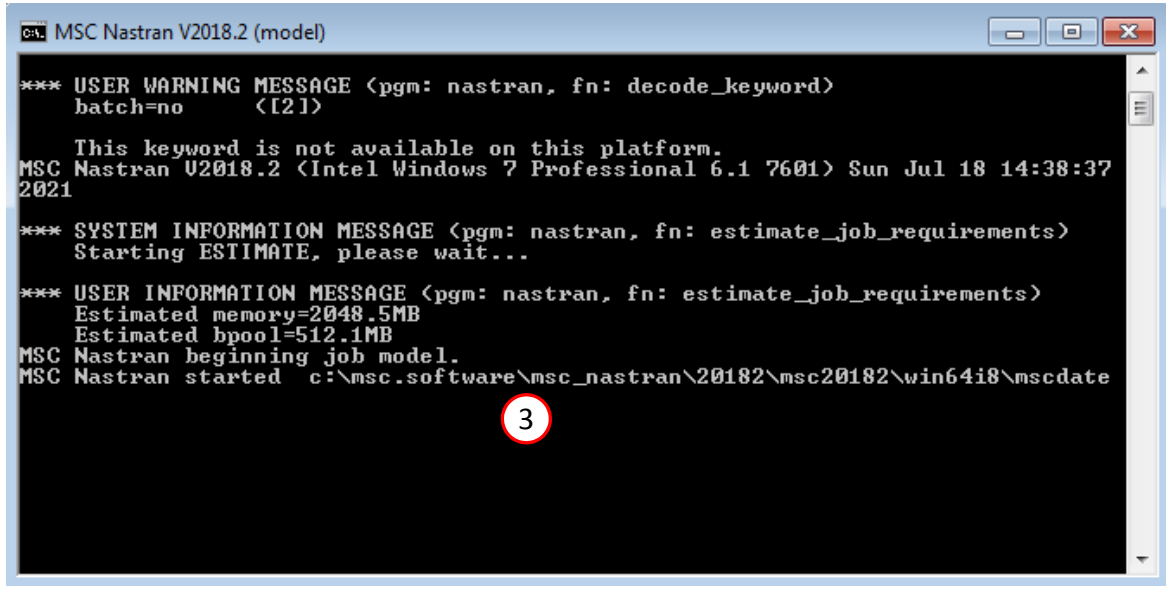
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
   cd ./nastran_working_directory
3) Use this command to start the process
   ./Start_MSC_Nastran.sh

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?"

Review Optimization Results

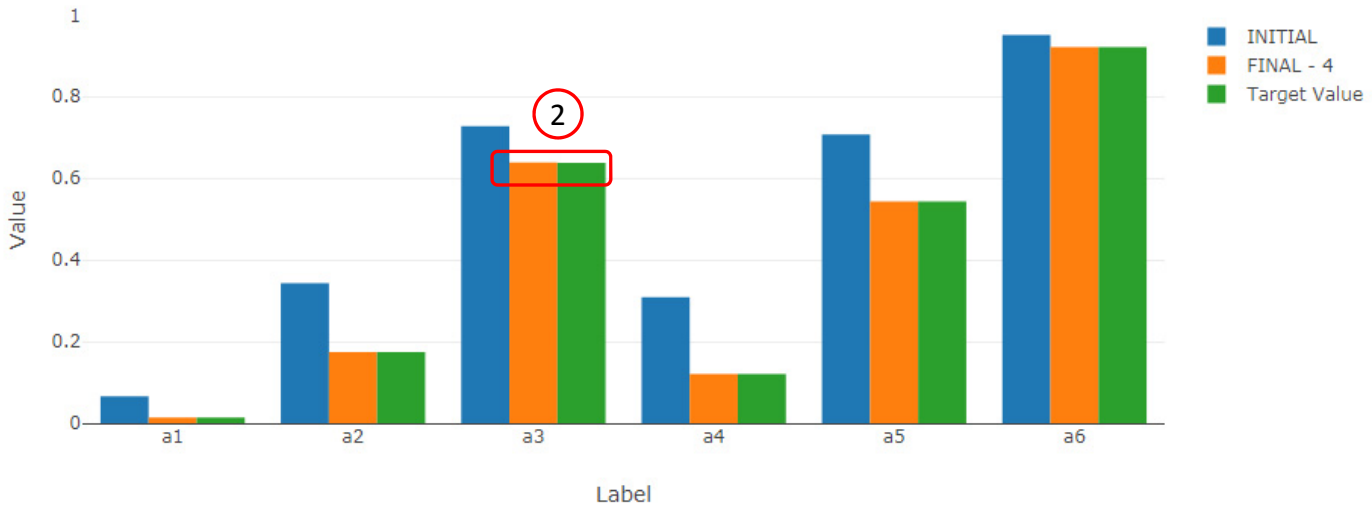
1. If “Option 1 – Auto Execute MSC Nastran” was used, bar charts will automatically be generated.
2. These charts can be used to compare the final values of the responses and the target values.

- The Bar Charts report 3 values for each response/label: The original/initial value, the final value after optimization and the target value.
- If the bars for both final and target values are equally leveled, the indicates an exact correlation.

SOL 200 Web App - Responses - Model Matching

Home

1 Model Matching Bar Charts



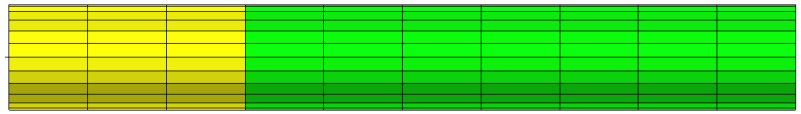
Select a response

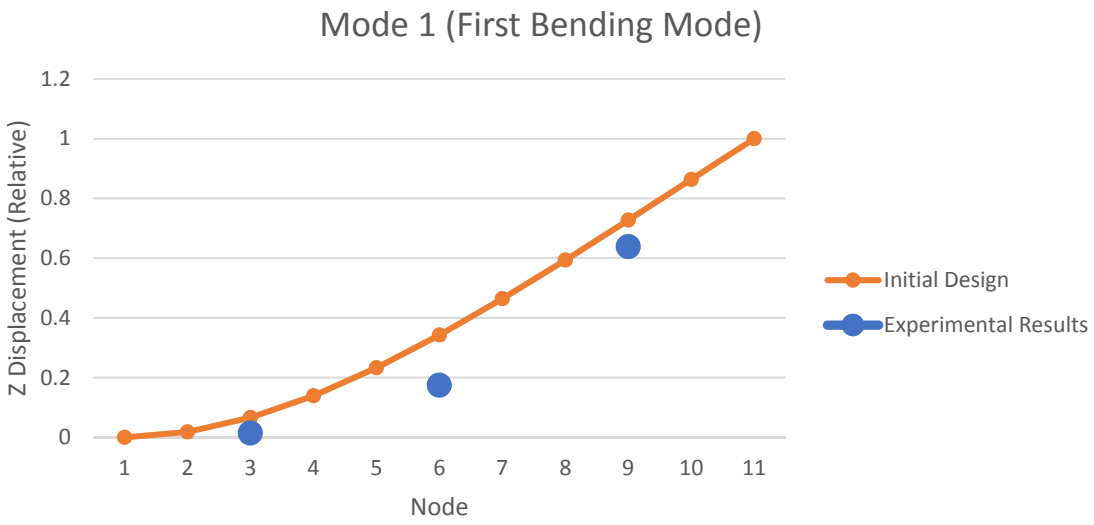
a1
a2
a3
a4
a5
a6

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 co grid 6
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	1.2040E-1**	5.431
Target Value	1.4300E-2	1.7410E-1	6.3810E-1	1.2040E-1	5.431

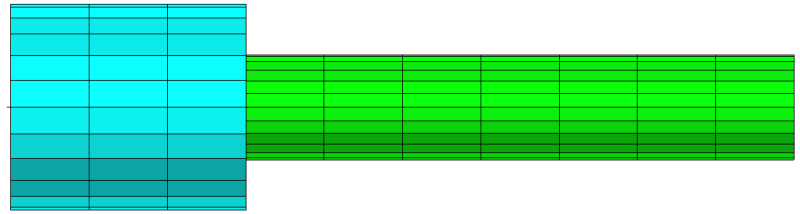
Results

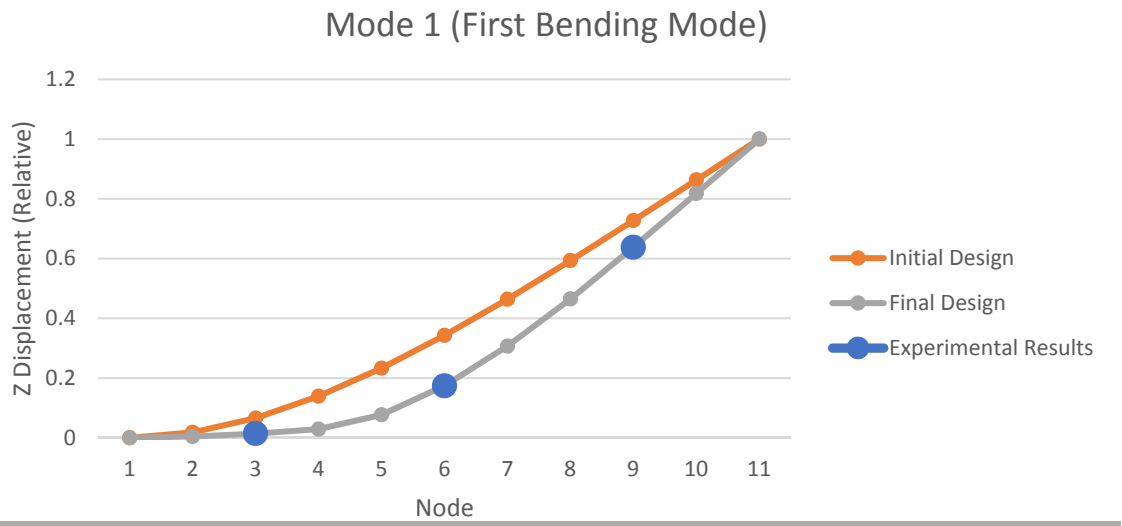
Before Optimization
Radius: 2 in





After Optimization
- Radius 3.93 in

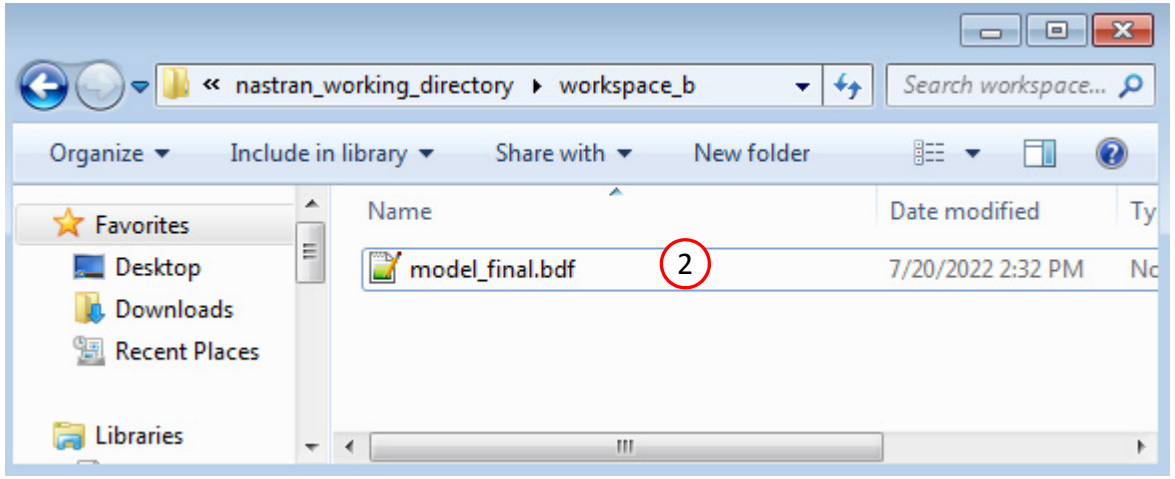




Update the Original Model

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.
```

1

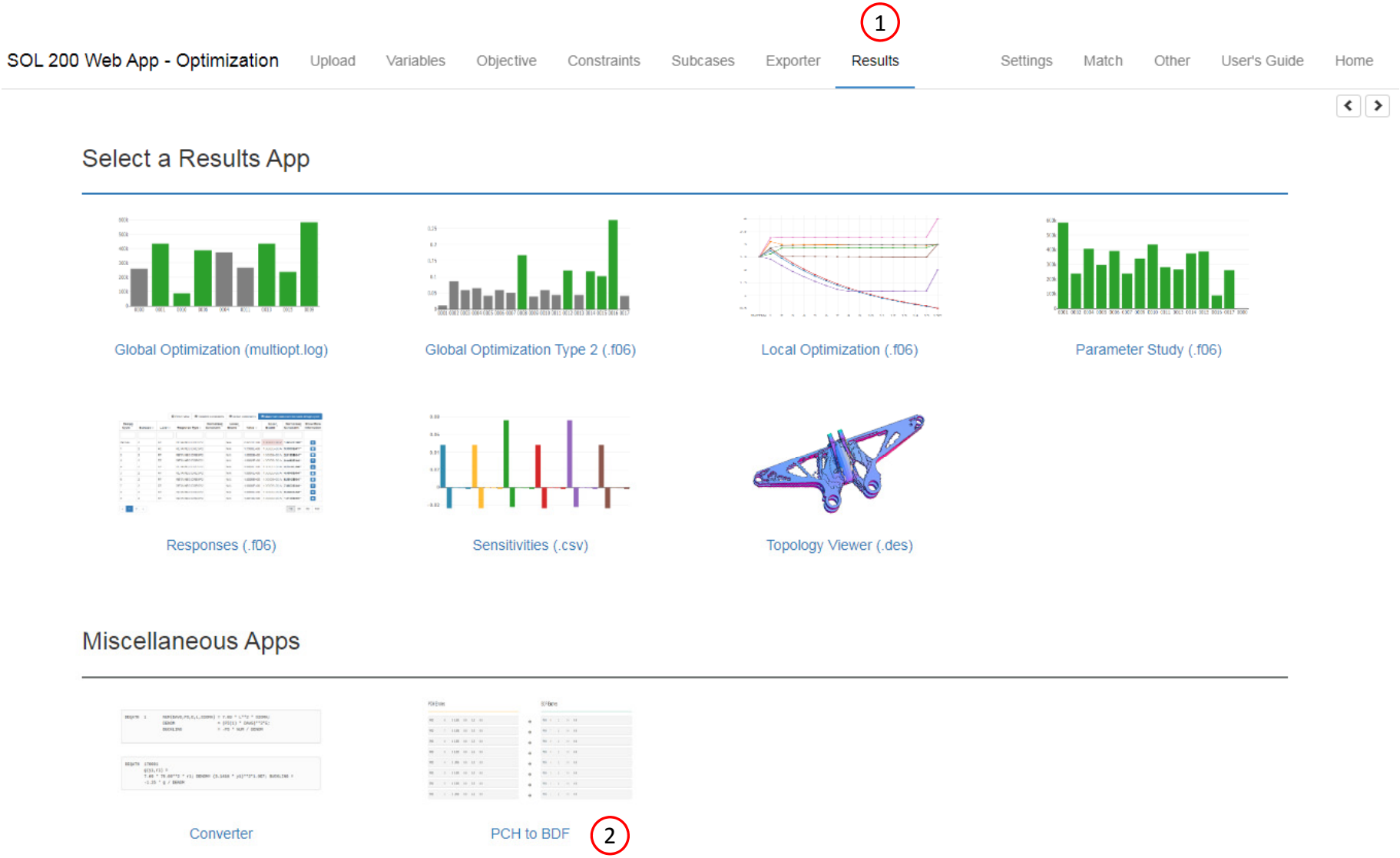
Updated BDF File (model_final.bdf)

```
$ 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.
```

3

Update the Original Model

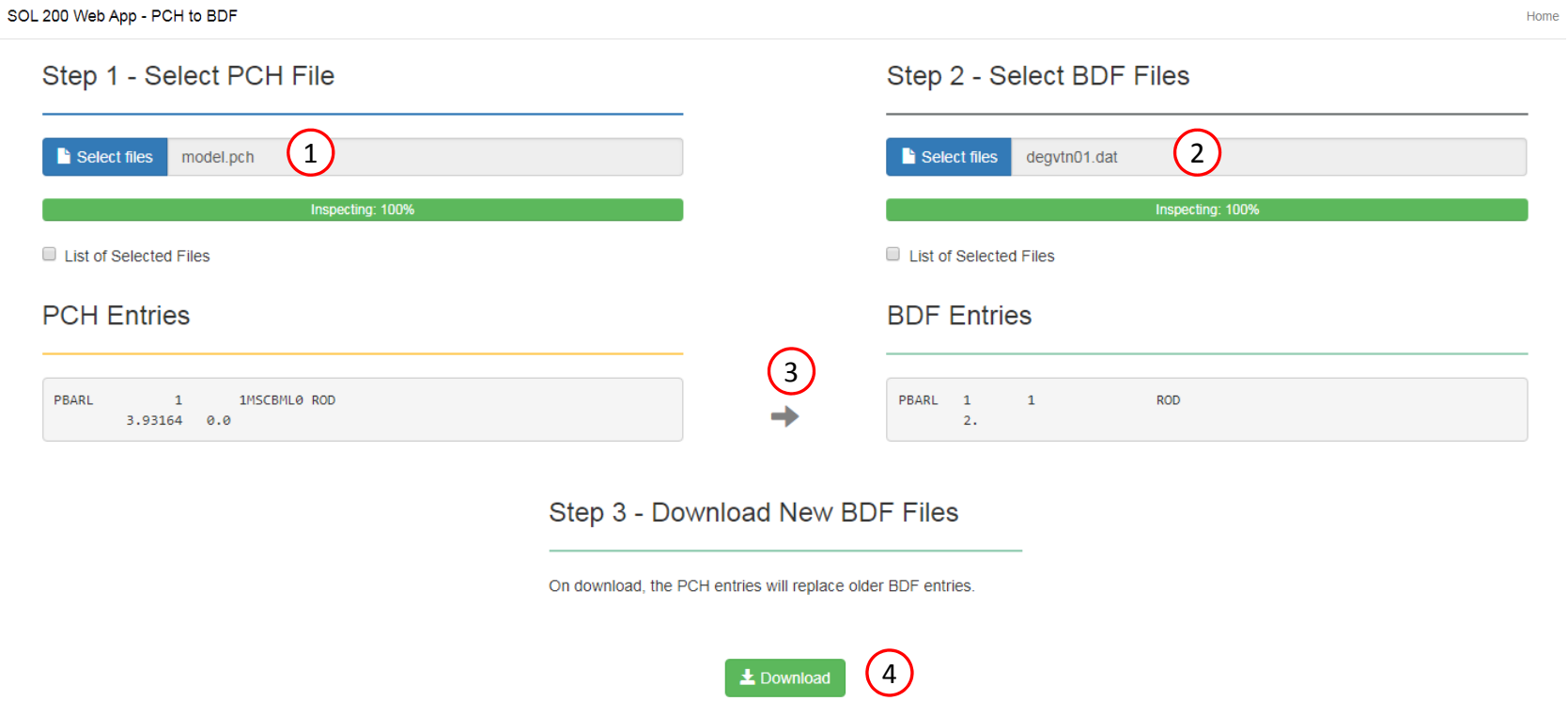
1. Click Results
2. Click PCH to BDF



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



Update the Original Model

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

degvtn01.dat

```
23  PARAM,SPARSEDR,NO
24  PARAM   GRDPNT  0
25  CBAR    1       1       1       2       0.      1.      0.
26  CBAR    2       1       2       3       0.      1.      0.
27  CBAR    3       1       3       4       0.      1.      0.
28  CBAR    4       2       4       5       0.      1.      0.
29  CBAR    5       2       5       6       0.      1.      0.
30  CBAR    6       2       6       7       0.      1.      0.
31  CBAR    7       2       7       8       0.      1.      0.
32  CBAR    8       2       8       9       0.      1.      0.
33  CBAR    9       2       9       10      0.      1.      0.
34  CBAR    10      2       10      11      0.      1.      0.
35  GRID    1               0.      0.      0.
36  GRID    2               3.      0.      0.
37  GRID    3               6.      0.      0.
38  GRID    4               9.      0.      0.
39  GRID    5               12.     0.      0.
40  GRID    6               15.     0.      0.
41  GRID    7               18.     0.      0.
42  GRID    8               21.     0.      0.
43  GRID    9               24.     0.      0.
44  GRID    10              27.     0.      0.
45  GRID    11              30.     0.      0.
46  $
47  $ Elements and Element Properties for region : Section_1
48  PBARL   1       1               ROD
49          2.
50  $ Elements and Element Properties for region : Section_2
51  PBARL   2       1               ROD
52          2.
53  $
54  $ Material Record : Aluminum
55  $ Description of Material : Date: 17-Apr-18          Time: 17:36:49
56  MAT1    1       1.+7            .3      .01
57  $
58  SPC1    1       123456  1
59  SPC1    1       26      1       THRU    11
60  $
61  EIGR    1       MGIV                            4
62          MAX
63  $
64  PARAM   POST    1
65  ENDDATA
66
```

Original BDF/DAT File

1

degvtn01.dat

```
23  PARAM,SPARSEDR,NO
24  PARAM   GRDPNT  0
25  CBAR    1       1       1       2       0.      1.      0.
26  CBAR    2       1       2       3       0.      1.      0.
27  CBAR    3       1       3       4       0.      1.      0.
28  CBAR    4       2       4       5       0.      1.      0.
29  CBAR    5       2       5       6       0.      1.      0.
30  CBAR    6       2       6       7       0.      1.      0.
31  CBAR    7       2       7       8       0.      1.      0.
32  CBAR    8       2       8       9       0.      1.      0.
33  CBAR    9       2       9       10      0.      1.      0.
34  CBAR    10      2       10      11      0.      1.      0.
35  GRID    1               0.      0.      0.
36  GRID    2               3.      0.      0.
37  GRID    3               6.      0.      0.
38  GRID    4               9.      0.      0.
39  GRID    5               12.     0.      0.
40  GRID    6               15.     0.      0.
41  GRID    7               18.     0.      0.
42  GRID    8               21.     0.      0.
43  GRID    9               24.     0.      0.
44  GRID    10              27.     0.      0.
45  GRID    11              30.     0.      0.
46  $
47  $ Elements and Element Properties for region : Section_1
48  PBARL           1       1MSCBML0 ROD
49          3.93164   0.0
50  $ Elements and Element Properties for region : Section_2
51  PBARL   2       1               ROD
52          2.
53  $
54  $ Material Record : Aluminum
55  $ Description of Material : Date: 17-Apr-18          Time: 17:36:49
56  MAT1    1       1.+7            .3      .01
57  $
58  SPC1    1       123456  1
59  SPC1    1       26      1       THRU    11
60  $
61  EIGR    1       MGIV                            4
62          MAX
63  $
64  PARAM   POST    1
65  ENDDATA
66
```

Downloaded BDF/DAT File

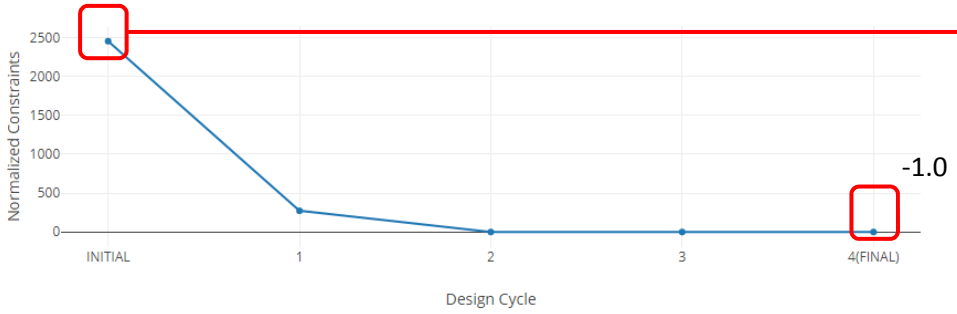
Inspection of MSC Nastran Results with the Post-processor Web App

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

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	DRESP2 ID	EQUATION ID
Sear	Search	Se	Search	Search	Sear	Search	Search	Search				
INITIAL	1001	R1	RETAINED DRESP2		N/A	2.4542E+00	~~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.

SOL 200 Web App - Responses

Home

Responses

Reset view | Violated constraints | Active constraints | Maximum constraint for each design cycle

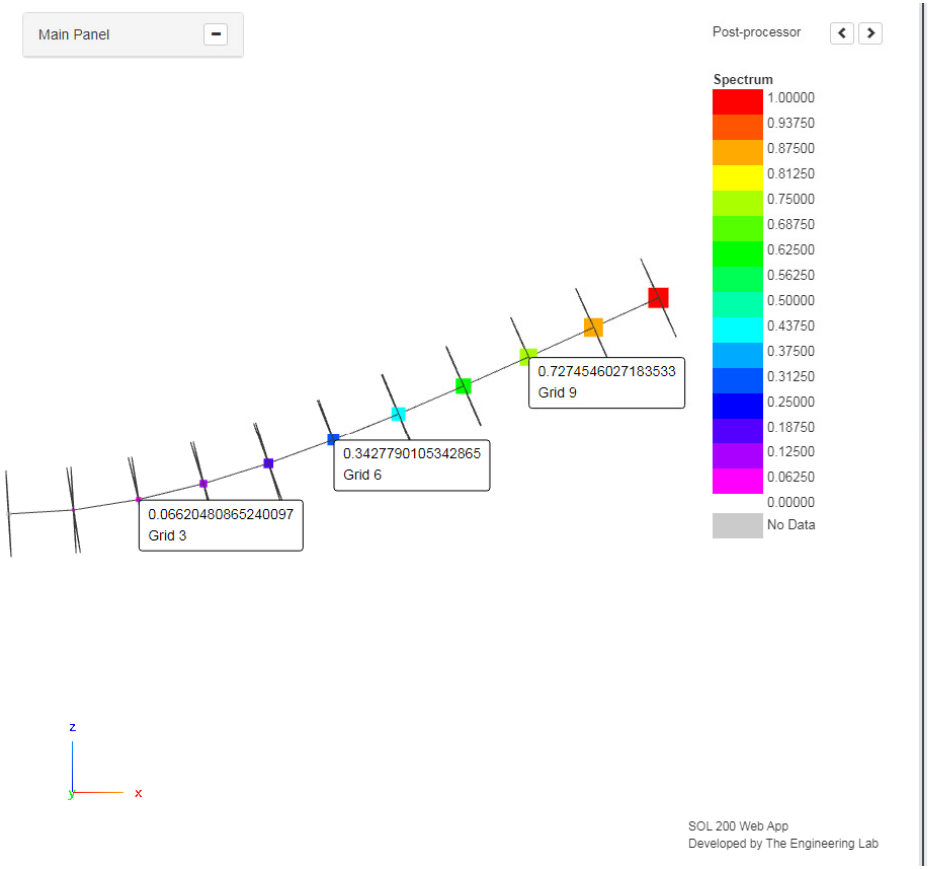
Design Cycle	Subcase	Label	Response Type	Normalized Constraint	Lower Bound	Value	Upper Bound	Normalized Constraint	Show More Information	designCycleNumber	GRID ID	COMPONENT NO.	MODE
Search	Searc	a	Search	Search	Sea	Search	Sea	Search					
INITIAL	1001	a1	EIGENVECTOR DISPLACEMENT		N/A	6.6205E-02	N/A			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

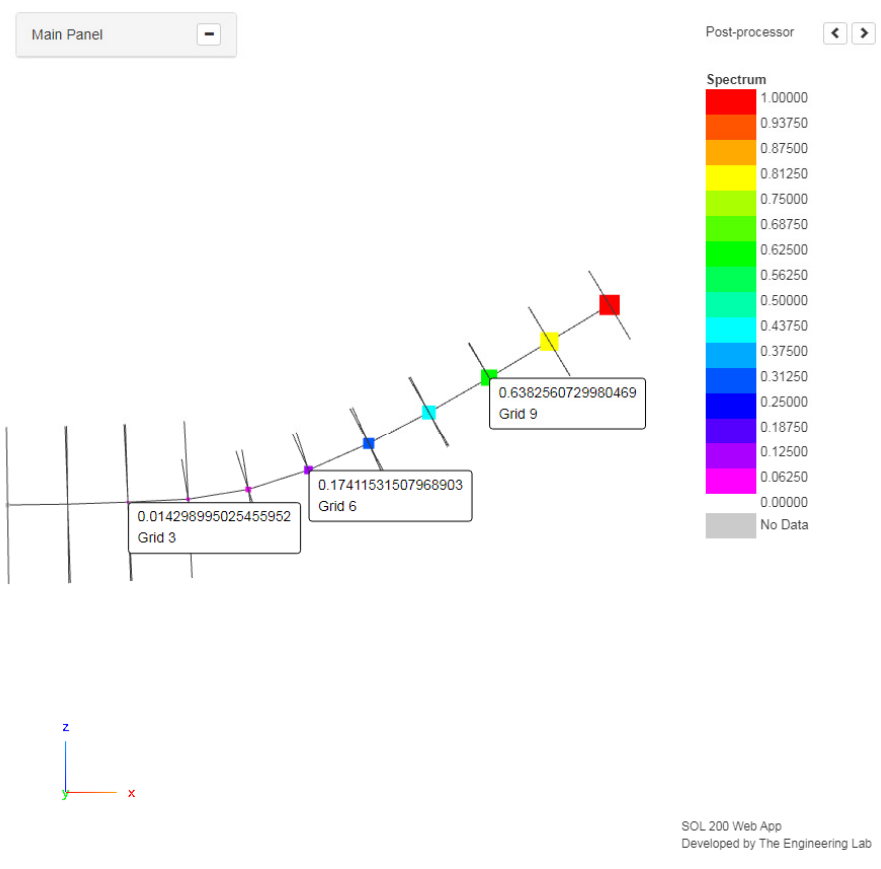
- The Post-processor web app is used to inspect the MSC Nastran results.
- Consider mode 1.
  - For the initial design, the z-component of the eigenvector for grid 3, 6 and 9 correspond to .066, .343 and .727.
  - For the final design, the z-component of the eigenvector for grid 3, 6 and 9 correspond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



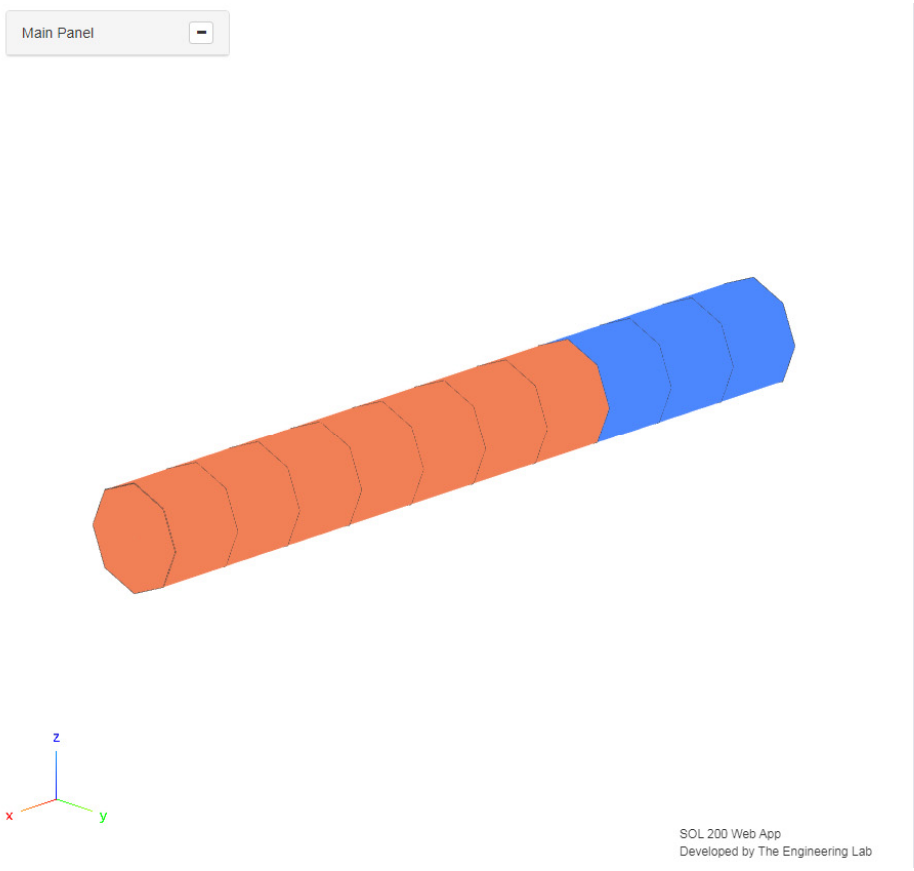
Final Design

Post-processor Web App

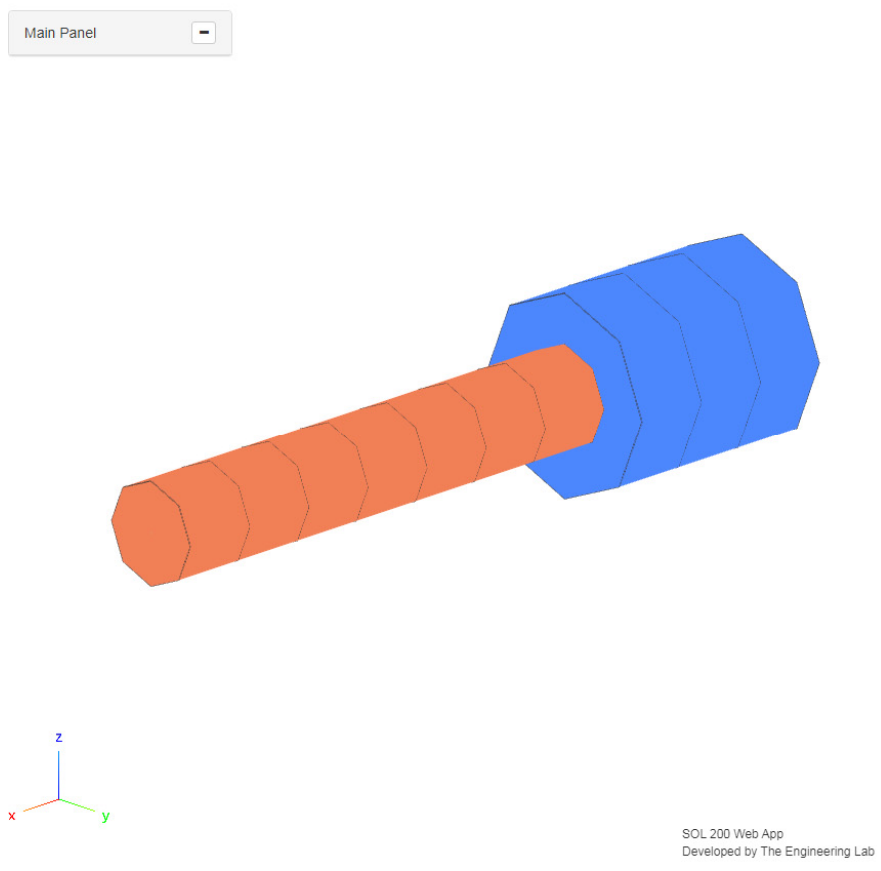
- The cross section of the CBAR elements of the initial and final design are compared.

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

Cross section of CBAR elements



Initial Design



Final Design

End of Tutorial

Appendix

Appendix Contents

- 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

*new 1 - Notepad++

```
SOL 200
CEND

$
TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
$
$ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
$ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
$ COMPUTED MODES AND ACTUAL MODES
$
$
SPC = 1
$
   DESOBJ(MIN) = 9000000
   $ DESGLB Slot
   $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1001
   ANALYSIS = MODES
   DESSUB = 40001001
   $ DRSPAN Slot

   DISP    = ALL
   METHOD = 1
$
BEGIN BULK

INCLUDE './design_model.bdf'

PARAM,SPARSEDR,NO
PARAM    GRDPNT   0
```

2

3

model.bdf

```
SOL 200
CEND

$
TITLE = EIGENVECTOR SENSITIVITY AND OPTIMIZATION
SUBTITLE = BEAM FROM UAI USER'S GUIDE PROBLEM 25-6
$
$ INITIAL DESIGN: AROOT=4.0, ATIP=4.0
$ OBJECTIVE FUNCTION IS TO MINIMIZE THE DIFF. BETWEEN
$ COMPUTED MODES AND ACTUAL MODES
$
$
SPC = 1
$
   DESOBJ(MIN) = 9000000
   $ DESGLB Slot
   $ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1001
   ANALYSIS = MODES
   DESSUB = 40001001
   $ DRSPAN Slot
modtrak = 800
   DISP    = ALL
   METHOD = 1
$
BEGIN BULK

INCLUDE './design_model.bdf'
modtrak, 800, 1, 100

PARAM,SPARSEDR,NO
PARAM    GRDPNT   0
```