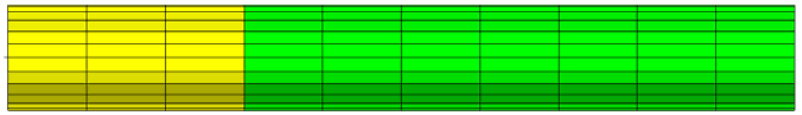
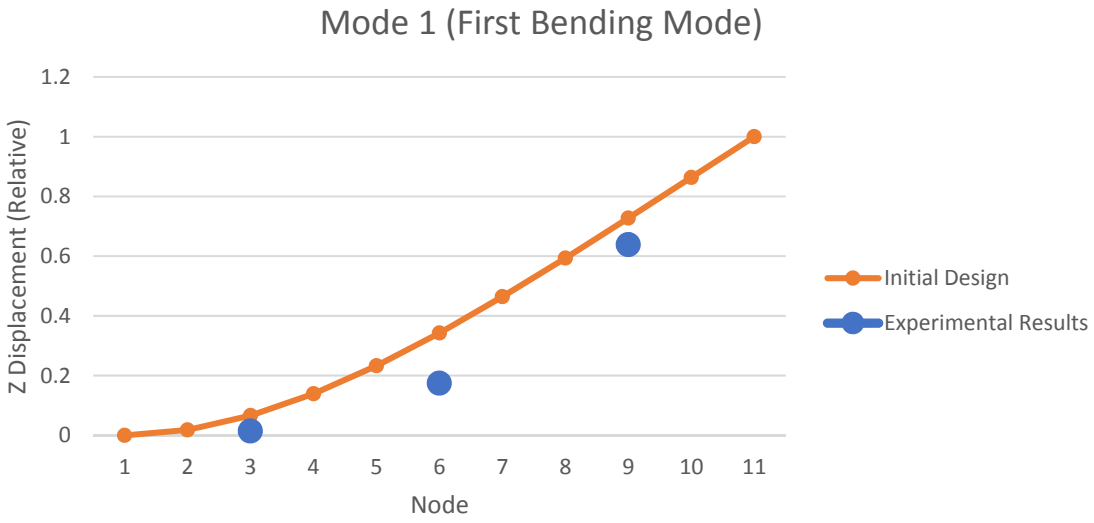
# Workshop - Model Matching / System Identification

AN MSC NASTRAN SOL 200 TUTORIAL

# Goal: Use optimization correlate test data and analysis results

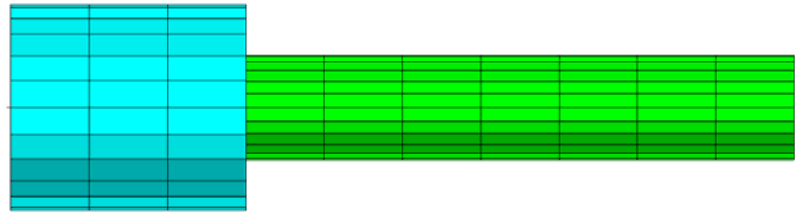
Before Optimization
Radius: 2 in

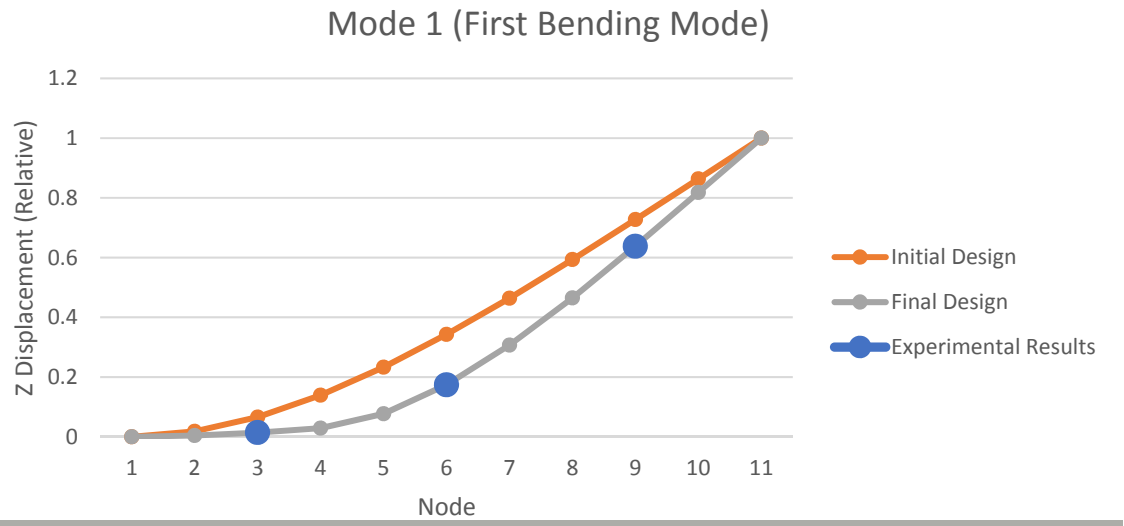





After Optimization

- Radius 3.93 in





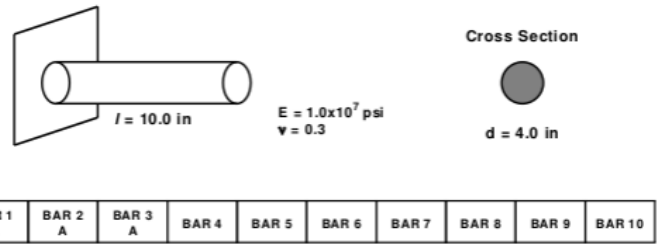
# Details of the structural model

**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:

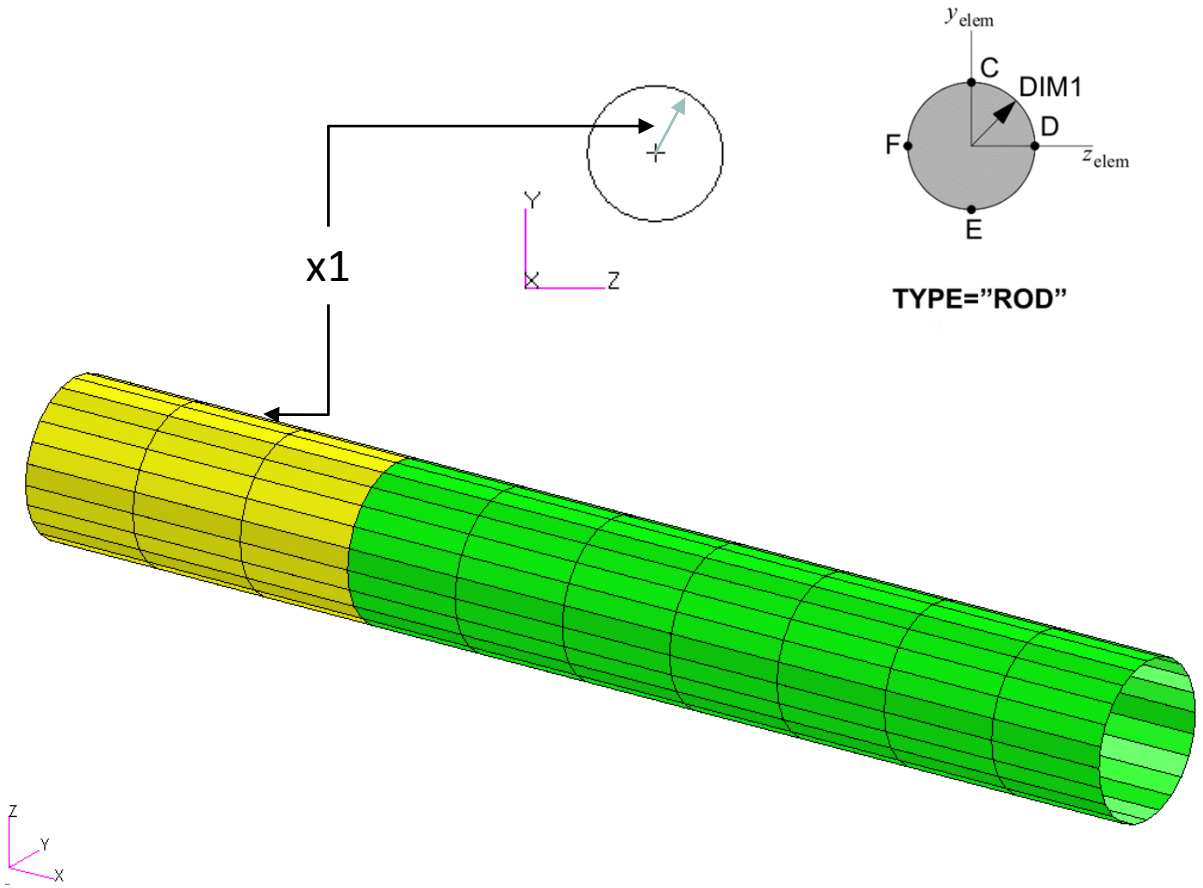
- Normal modes optimization
- Constraints on RMS error in mode shapes
- Frequency constraints
- Using an analytical response as the objective

**Figure 25-13. SYSTEM ID — SIMPLE BEAM MODEL**



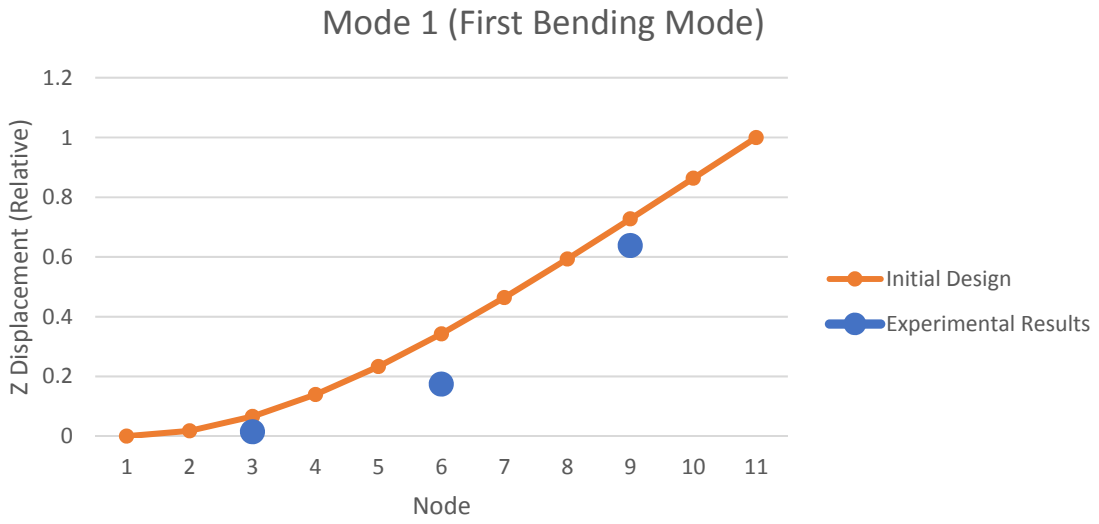


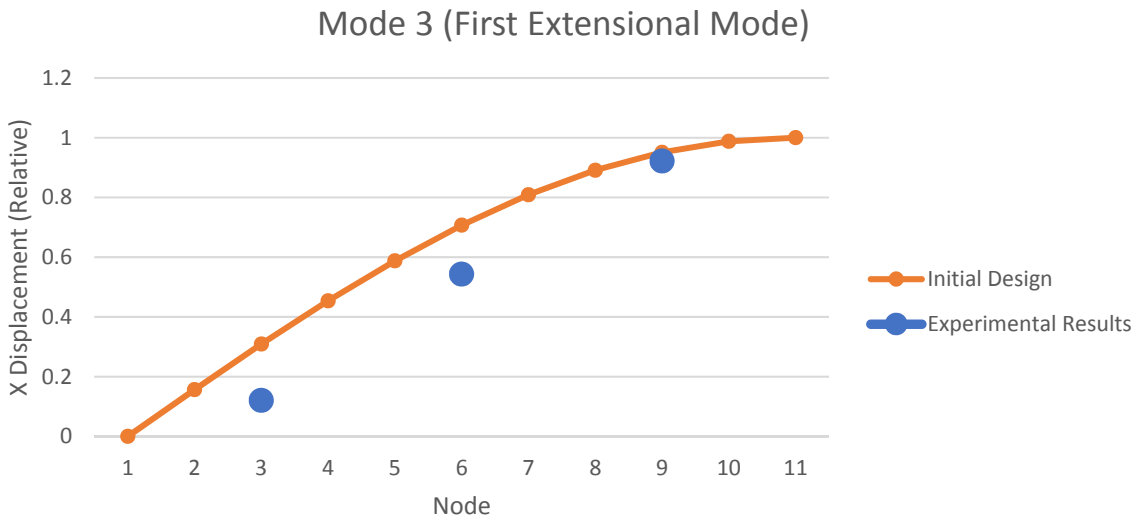

*UAI/NASTRAN User's Guide for Version 20.1*
*Chapter 25 - MULTIDISCIPLINARY DESIGN OPTIMIZATION -*
*25.6.6 System Identification*



# 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 |



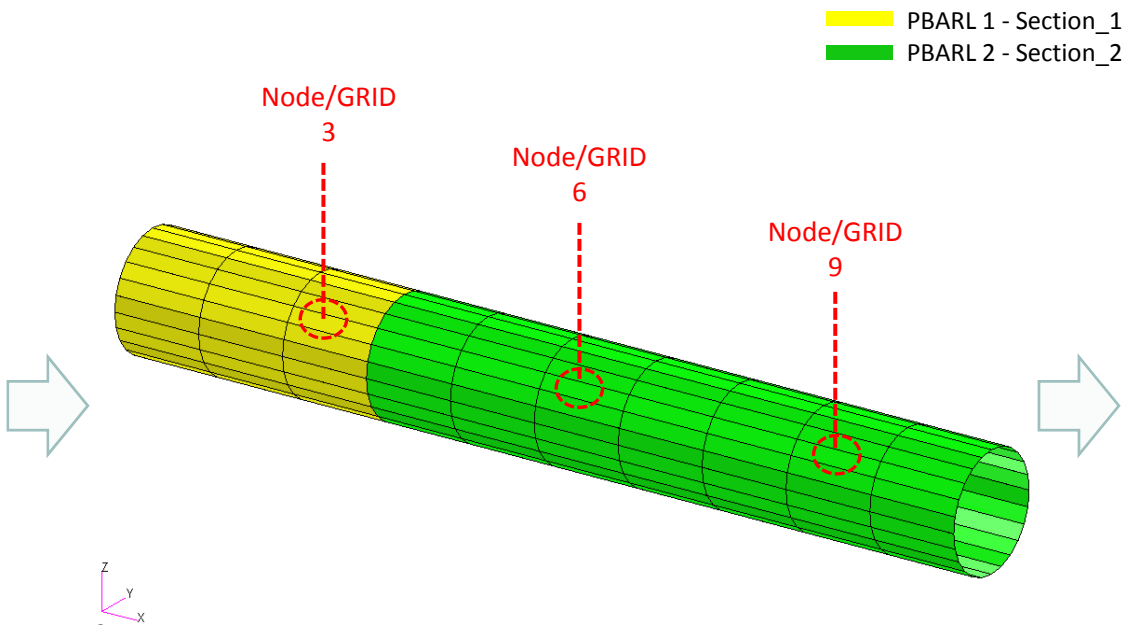



# Optimization Problem Statement

## 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

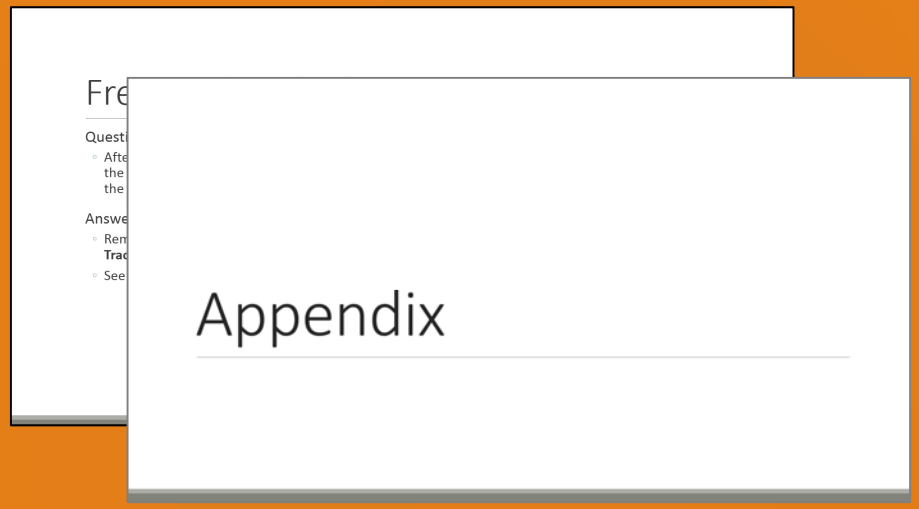
$R3 = \left(\frac{a6-.9216}{.9216}\right)^2$ R3 < .001

- 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 optimization questions
- Access to the MSC Nastran SOL 200 Web App

christian@ the-engineering-lab.com

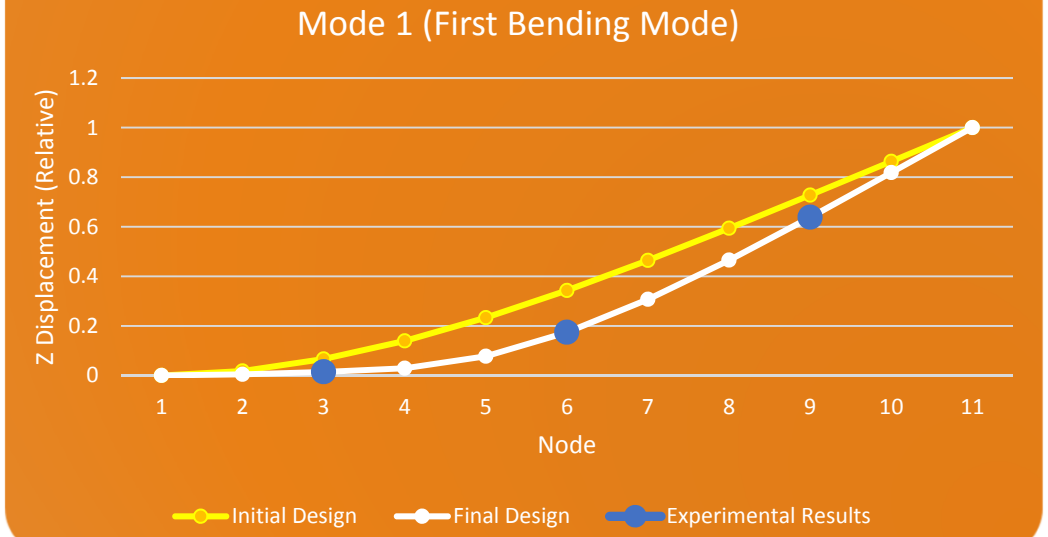
# Tutorial

# Tutorial Overview

1. Start with a .bdf or .dat file
2. Use the MSC Nastran 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

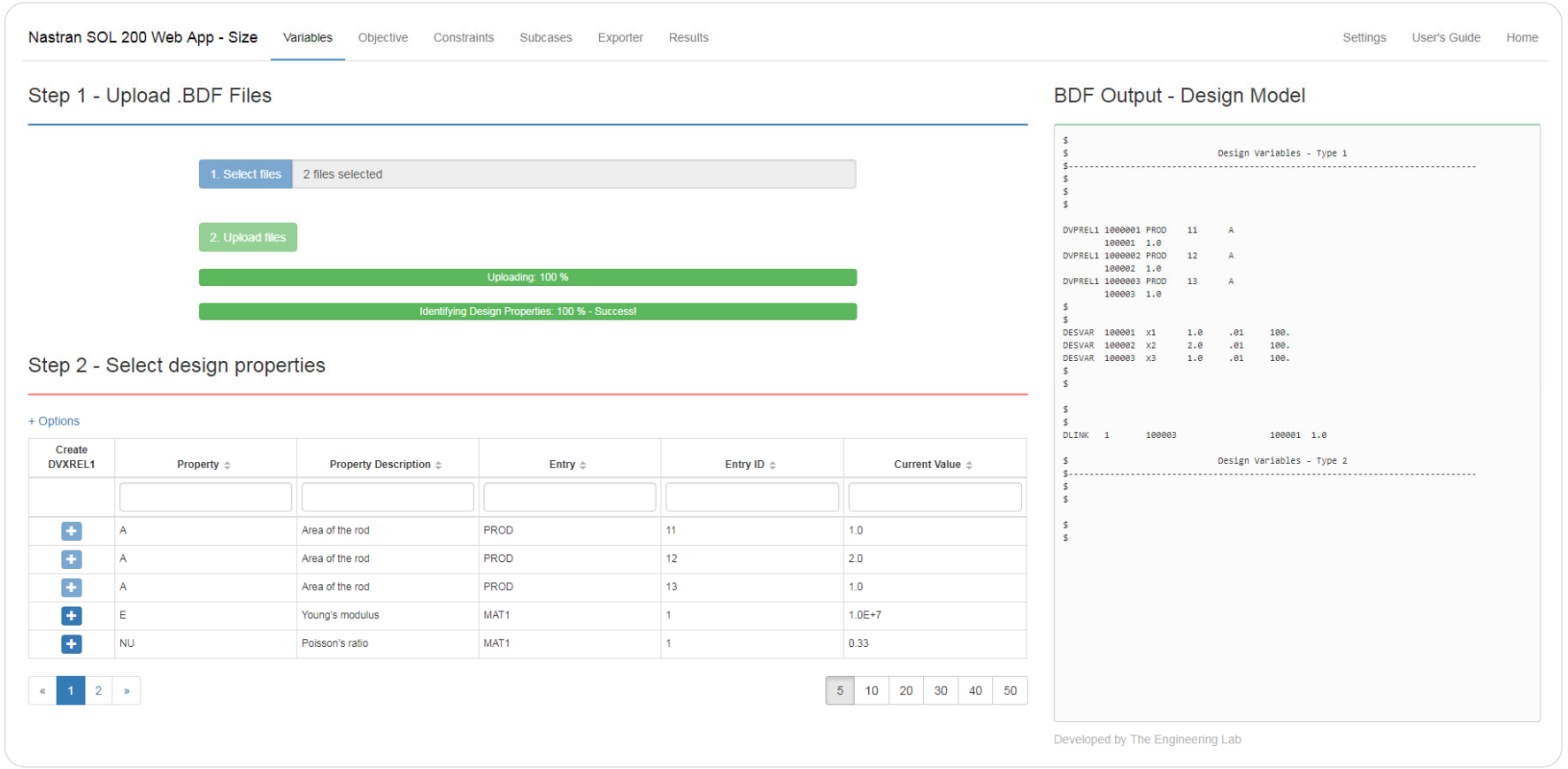
**Special Topics Covered**

**Model Matching** - The MSC Nastran 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.



# MSC Nastran SOL 200 Web App

SOL 1xx BDF

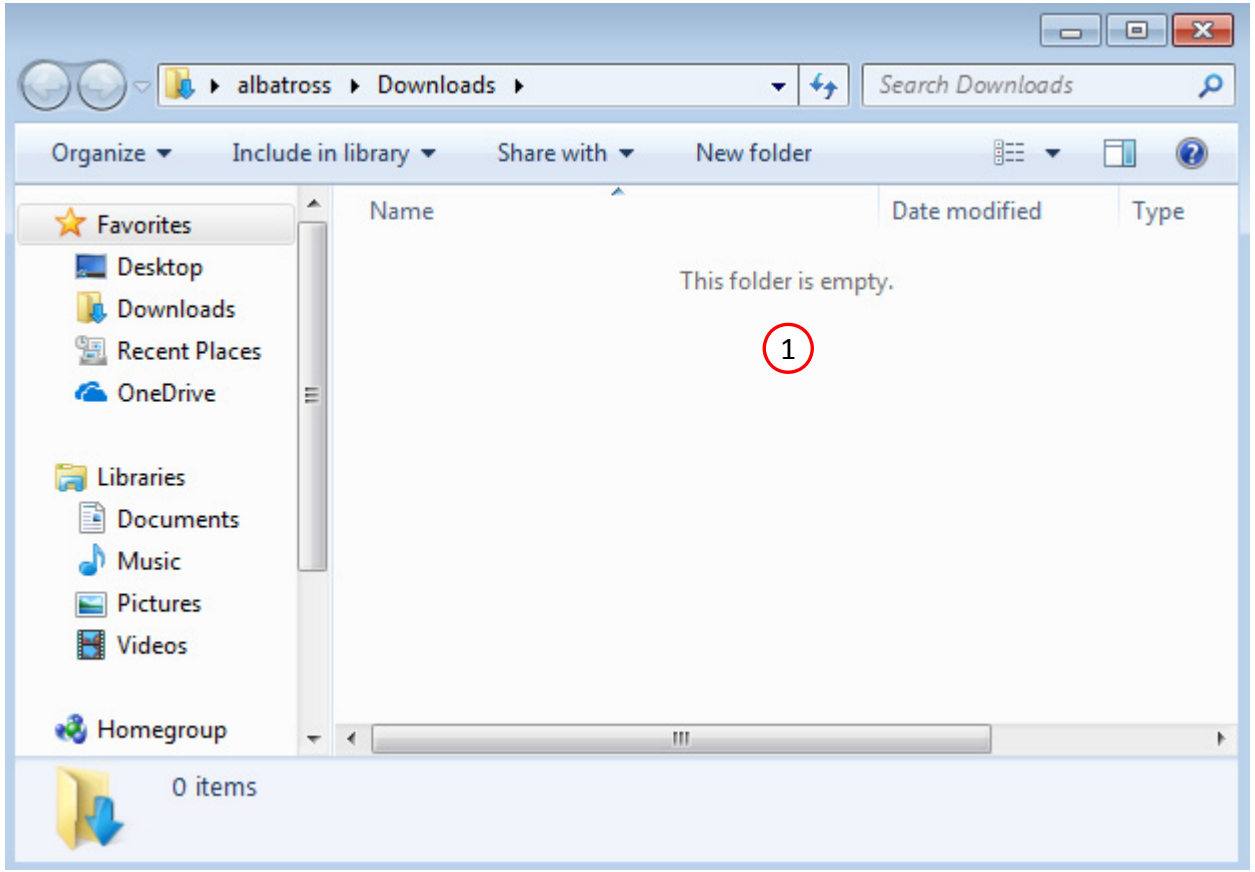



SOL 200 BDF

# Before Starting

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

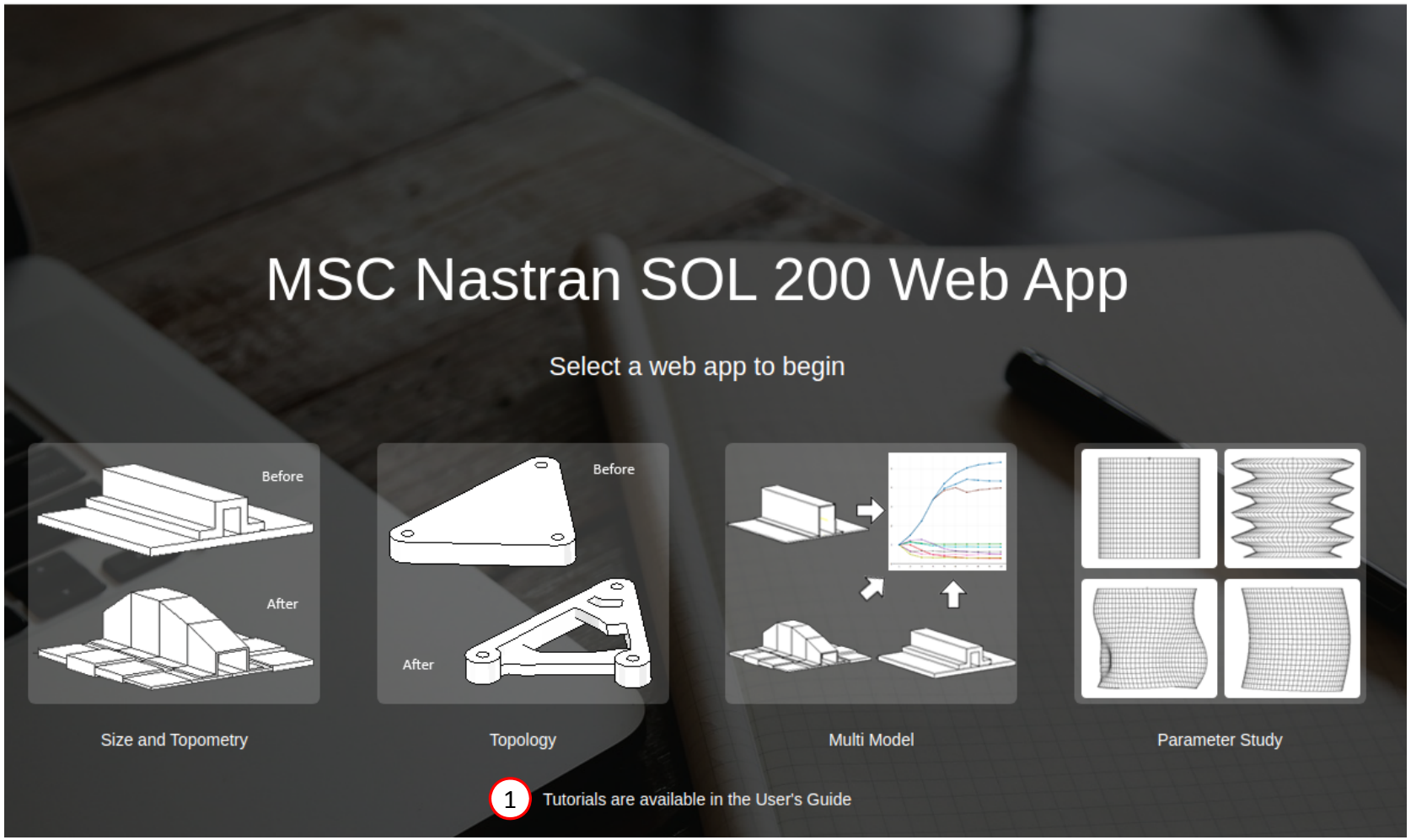
- Throughout this workshop, you will be working with multiple file types and directories such as:
  - .bdf/.dat
  - nastran_working_directory
  - .f06, .log, .pch, .h5, etc.
- To minimize confusion with files and folders, it is encouraged to start with a clean directory.



# Go to the User's Guide

1. Click on the indicated link

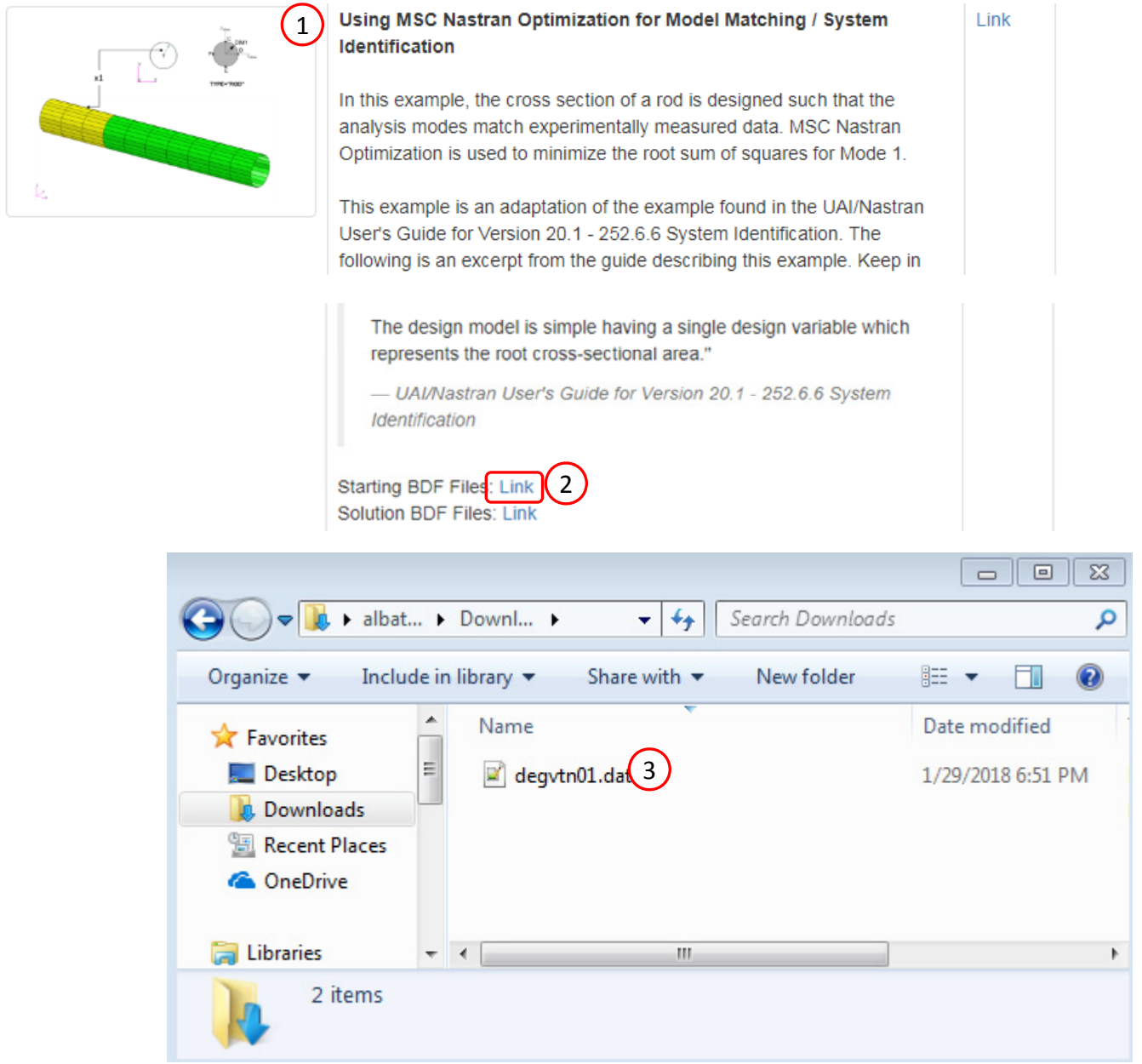
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



# Obtain Starting Files

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

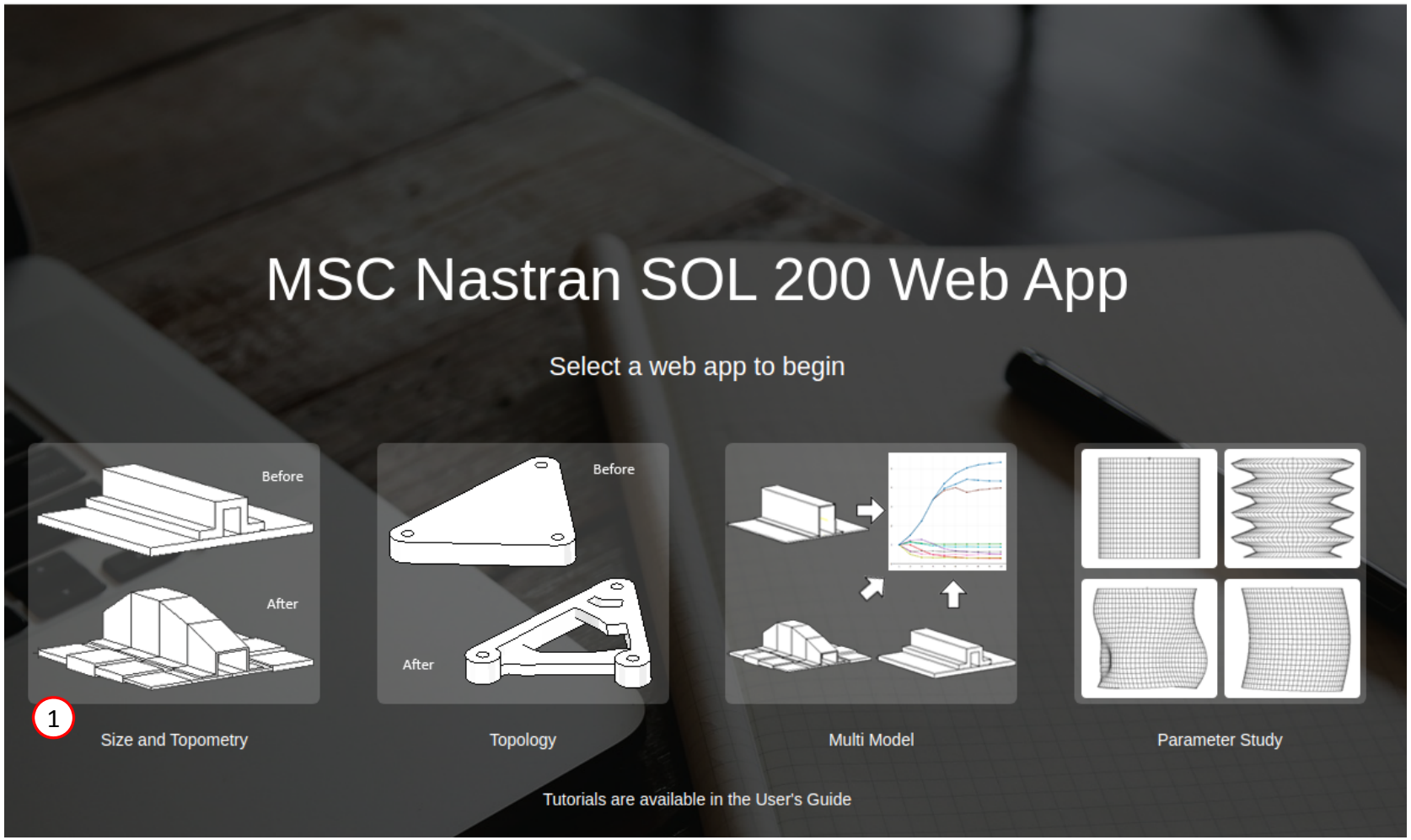
- When starting the procedure, all the necessary BDF files must be collected together.



# Open the Correct Page

1. Click on the indicated link

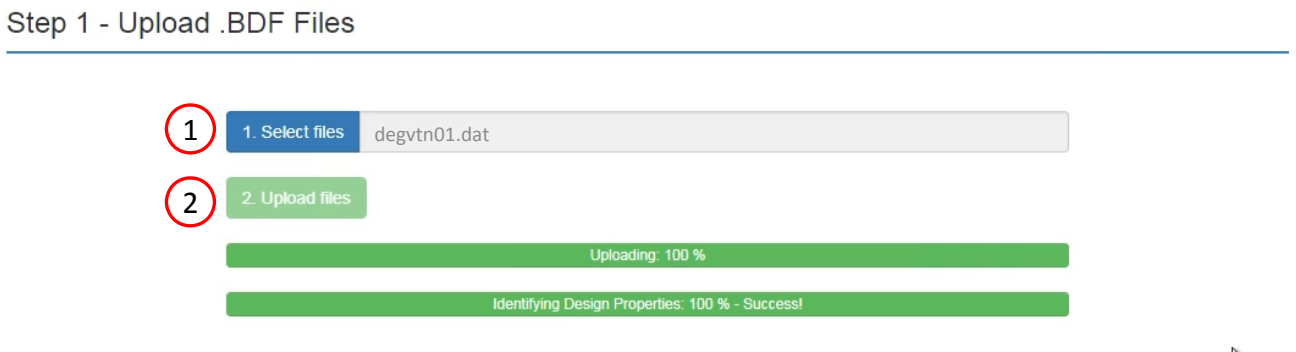
- MSC Nastran can perform many optimization types. The MSC Nastran SOL 200 Web App includes dedicated web apps for the following:
  - Size and Topometry Optimization
  - Topology Optimization
  - Global Optimization
  - Multi Model Optimization
- The web app also features the HDF5 Explorer, a web application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



# Upload BDF Files

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

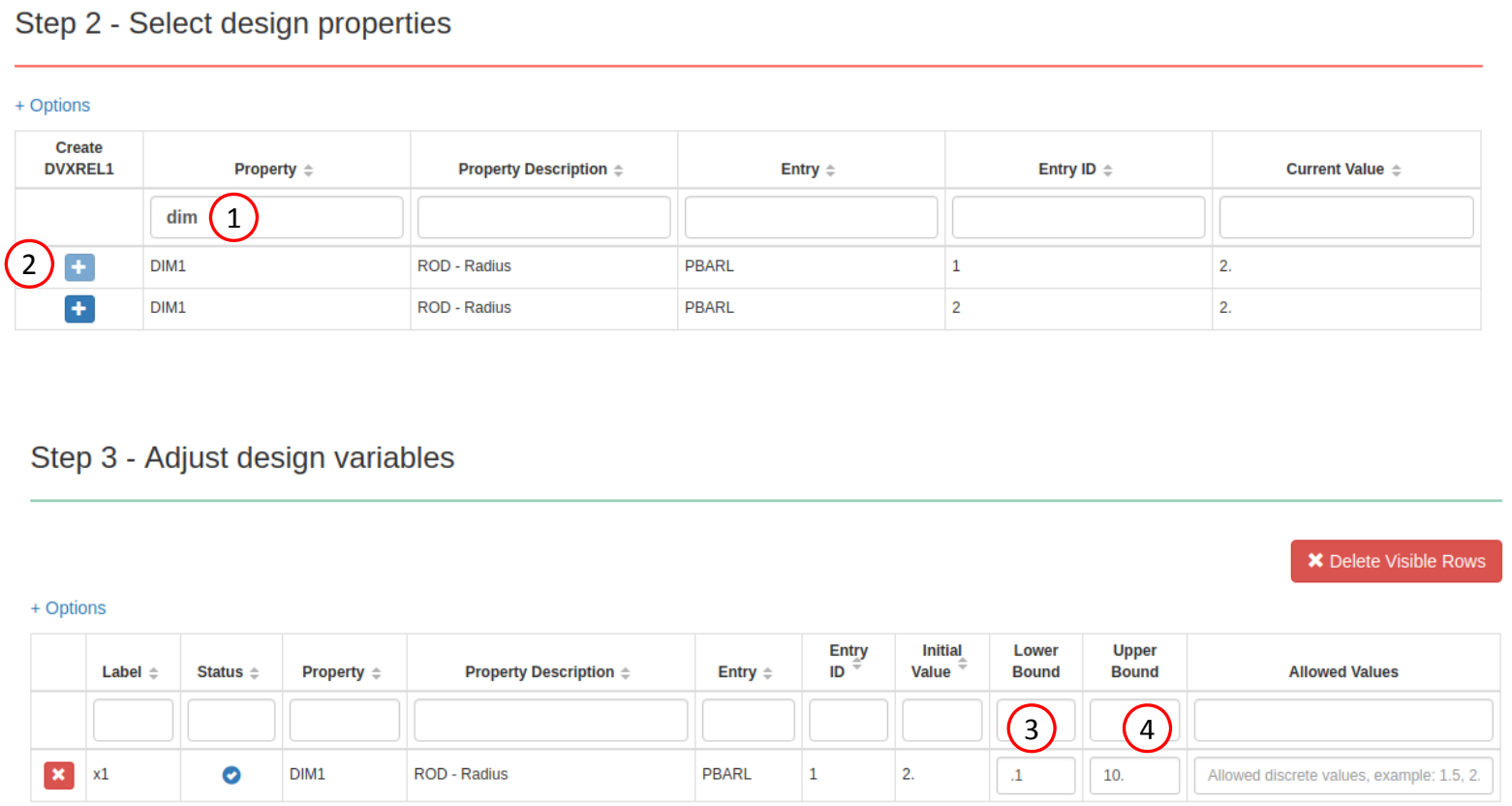
- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.



# 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

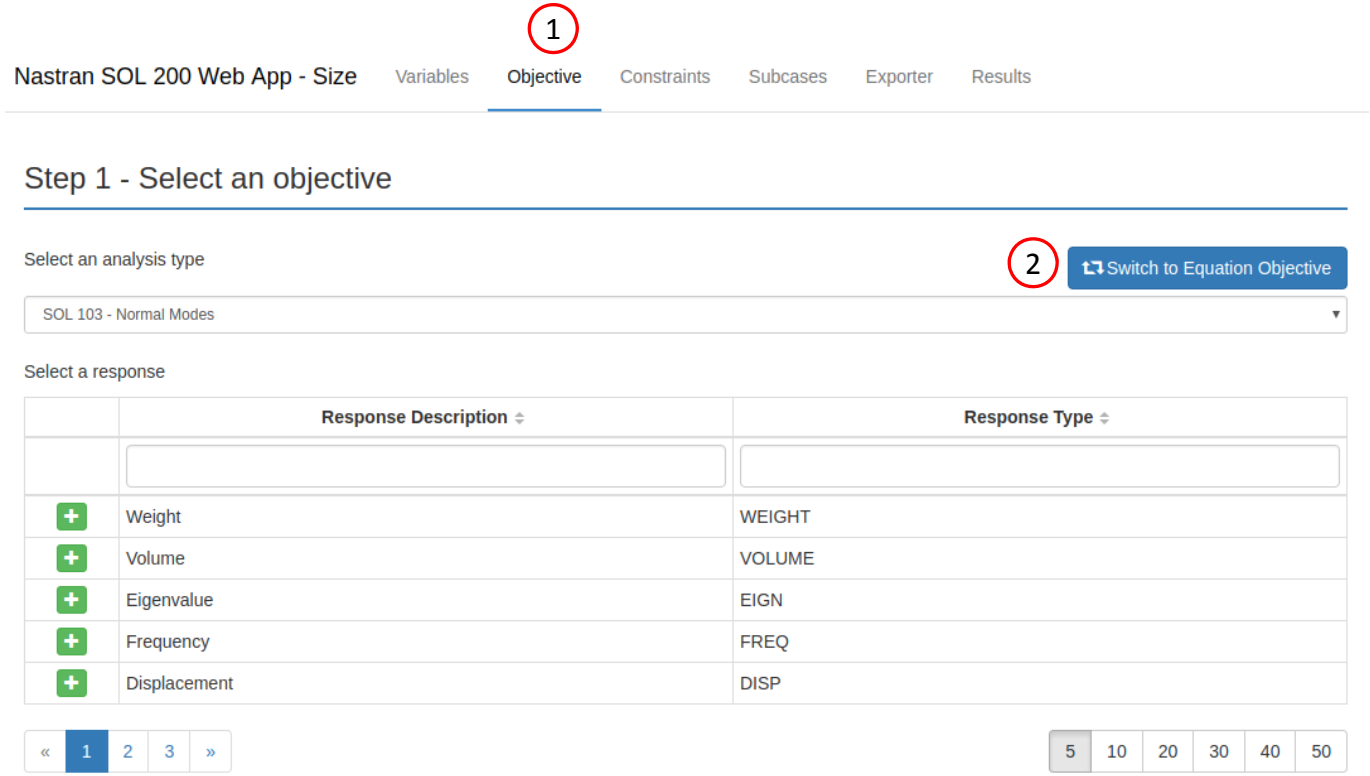
- Each step has hidden functionality for advanced users. The visibility is controlled by clicking + Options.
- If the property entry, e.g. PSHELL, was given a name in Patran, e.g. Car Door, the name can be shown by marking the checkbox titled Entry Name.



# Create Responses

1. Click Objective
2. Click Switch to Equation Objective

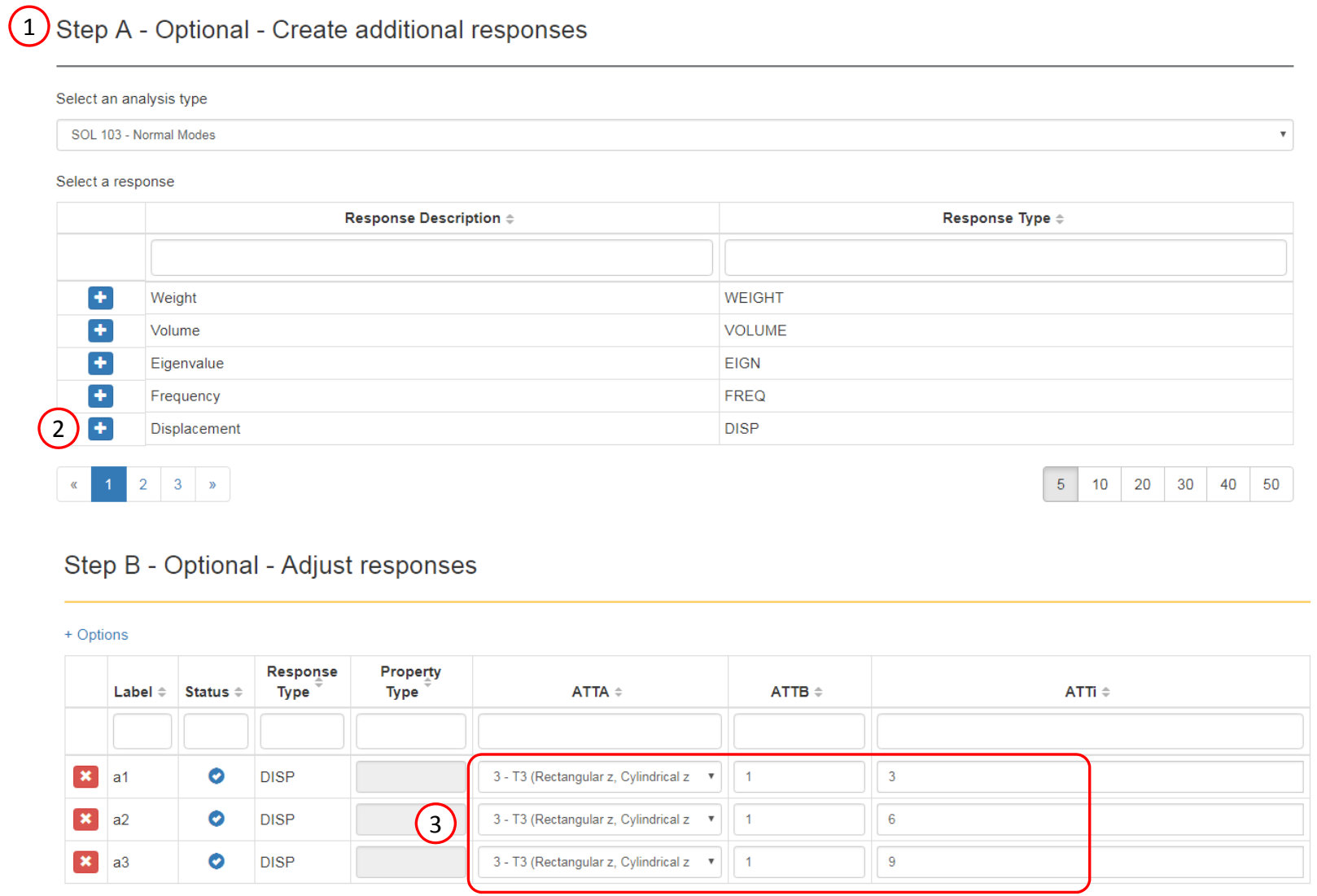
- The responses that are used for model matching must be defined. The response can be defined in the table titled “Step A – Optional – Create additional responses.” This table is accessible by first clicking the button titled “Switch to Equation Objective.”



# 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

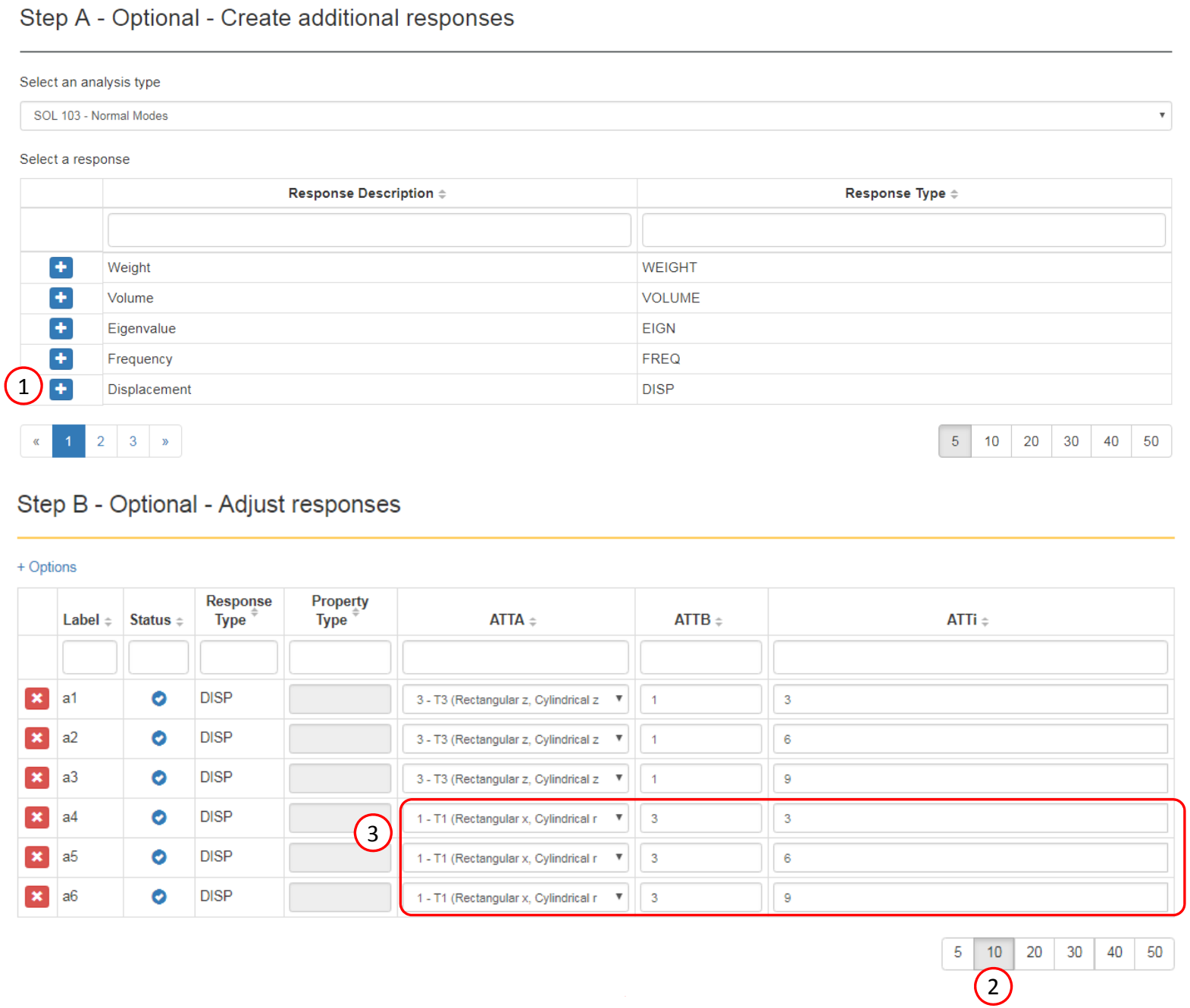
- These 3 responses correspond to the displacement of mode shape 1 at three grids in the 3/T3/z direction.



# 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

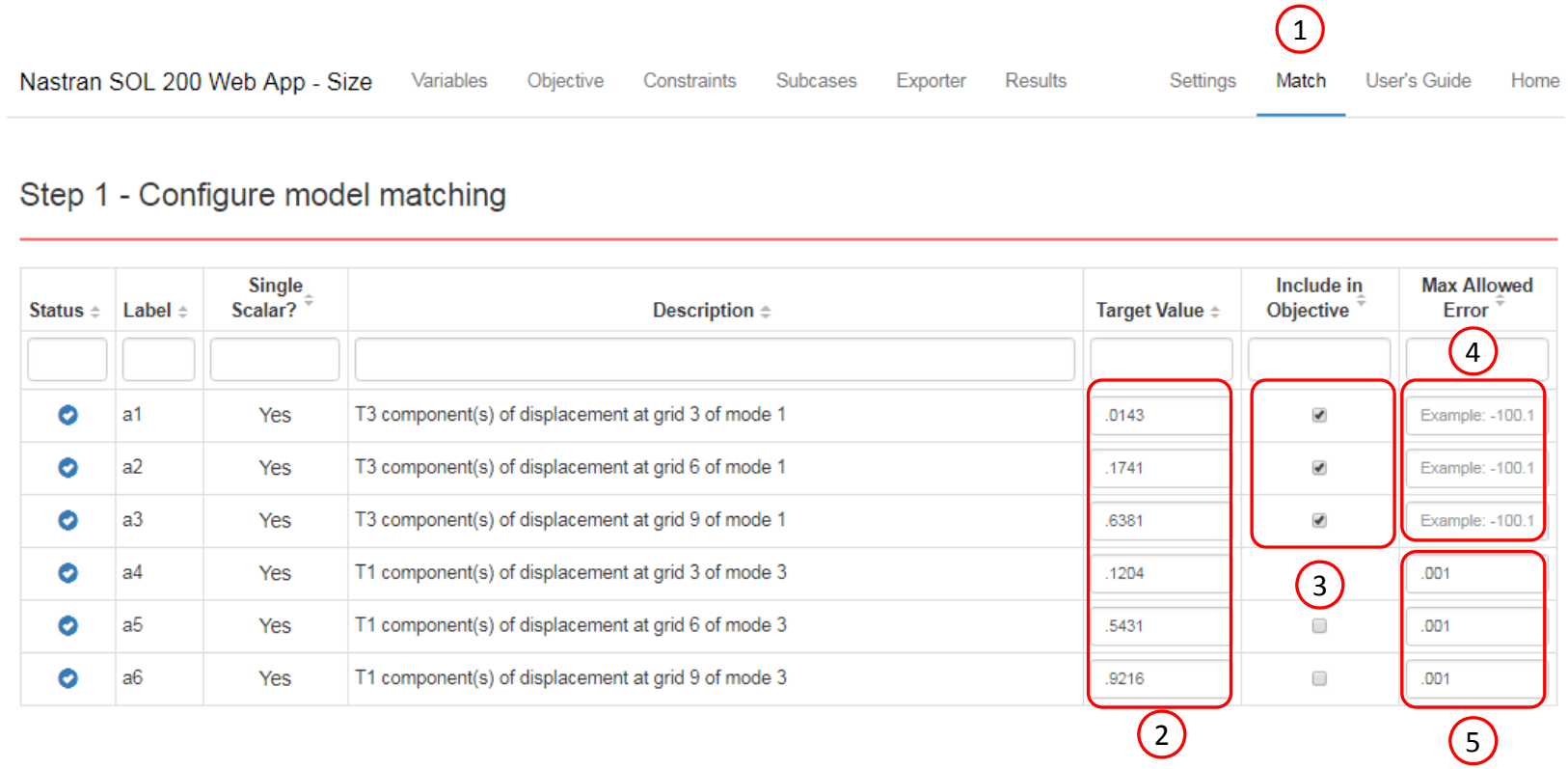
- The next 3 responses correspond to the displacement of mode shape 3 at three grids in the 1/T1/x direction.



# 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

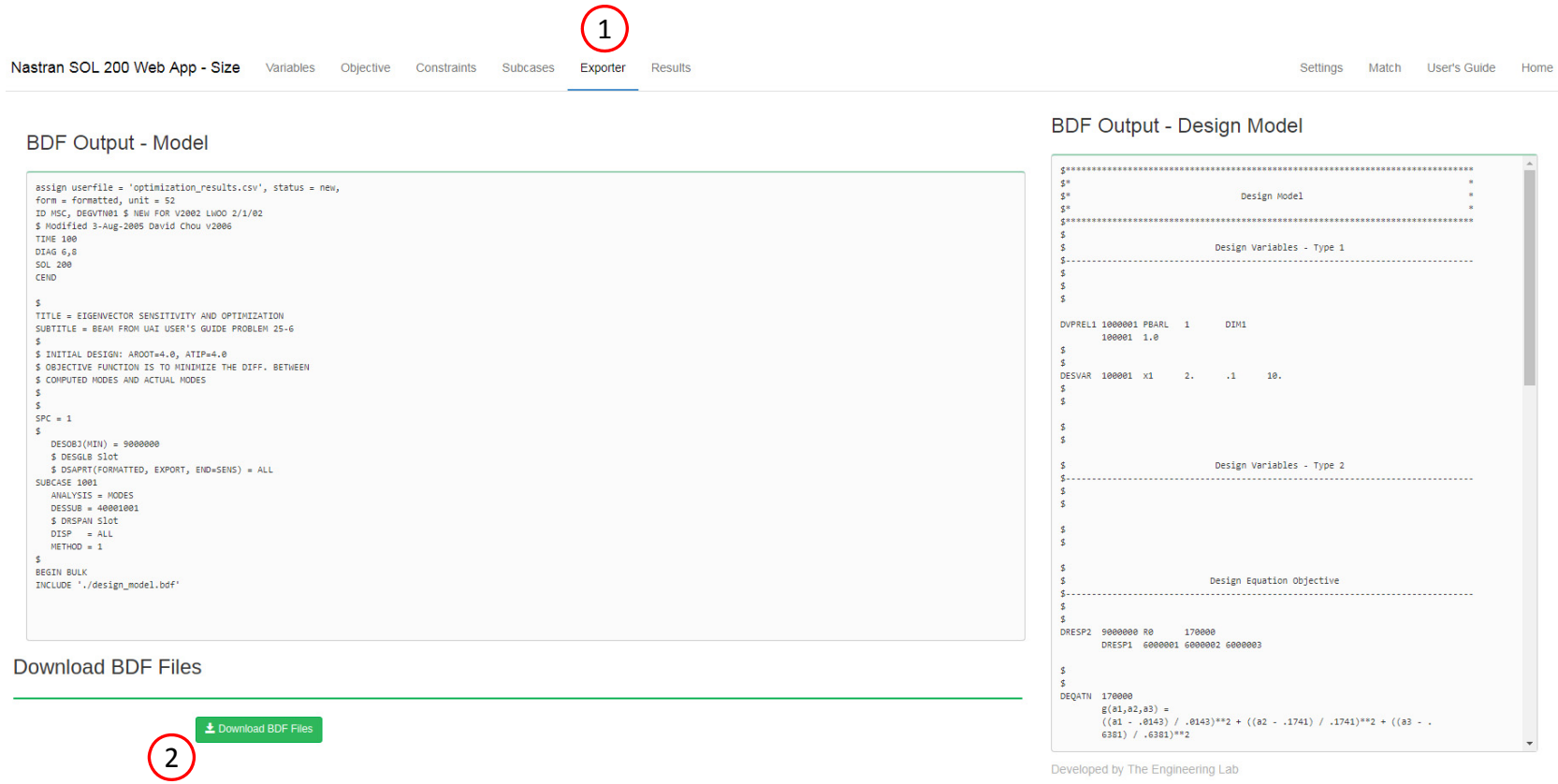
- The necessary objective and constraints are automatically generated. Refer to the Equation Objective and Equation Constraint sections.



# 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”

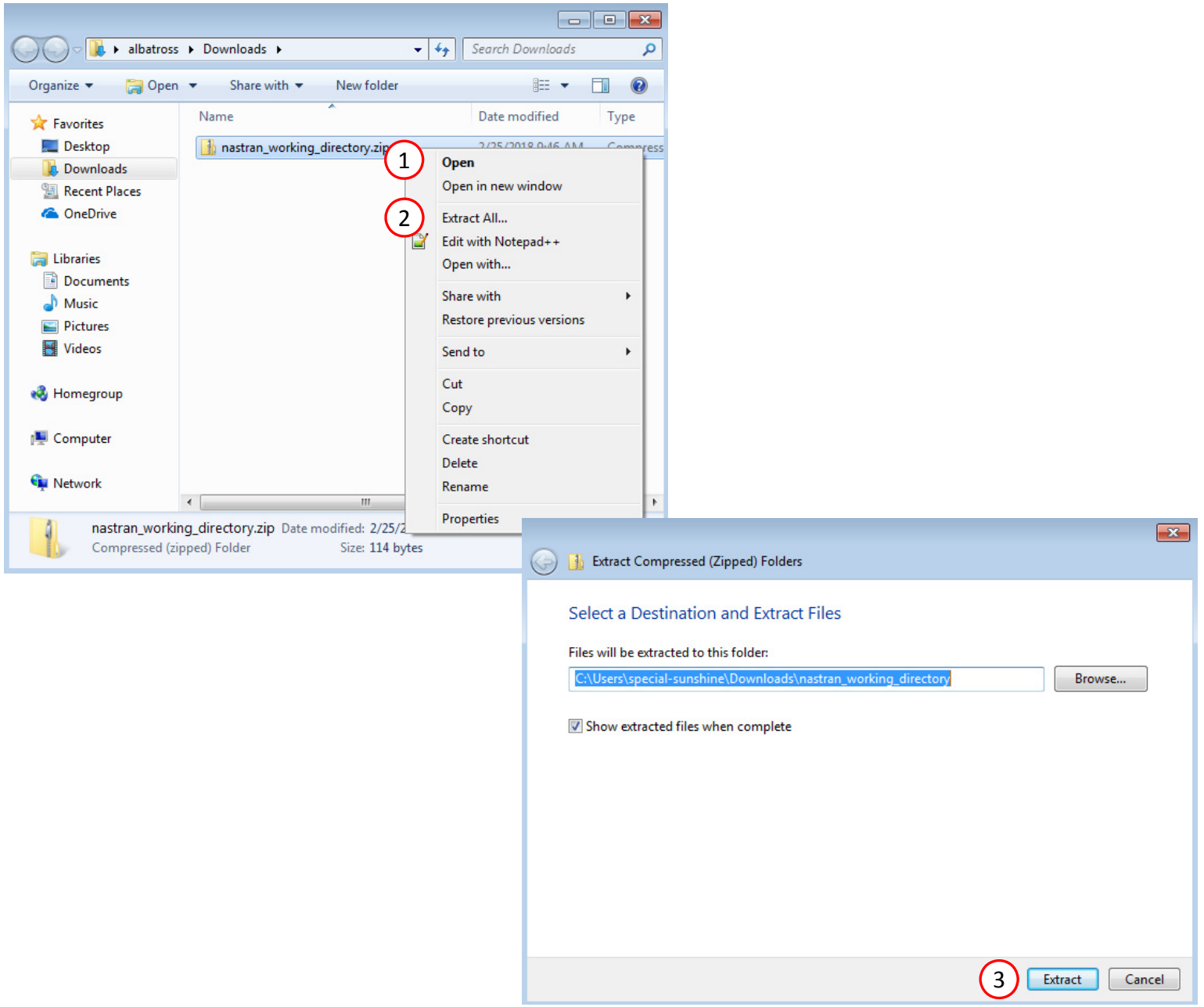


# Perform the Optimization with Nastran SOL 200

A new .zip file has been downloaded

1. Right click on the file
2. Click Extract All
3. Click Extract on the following window

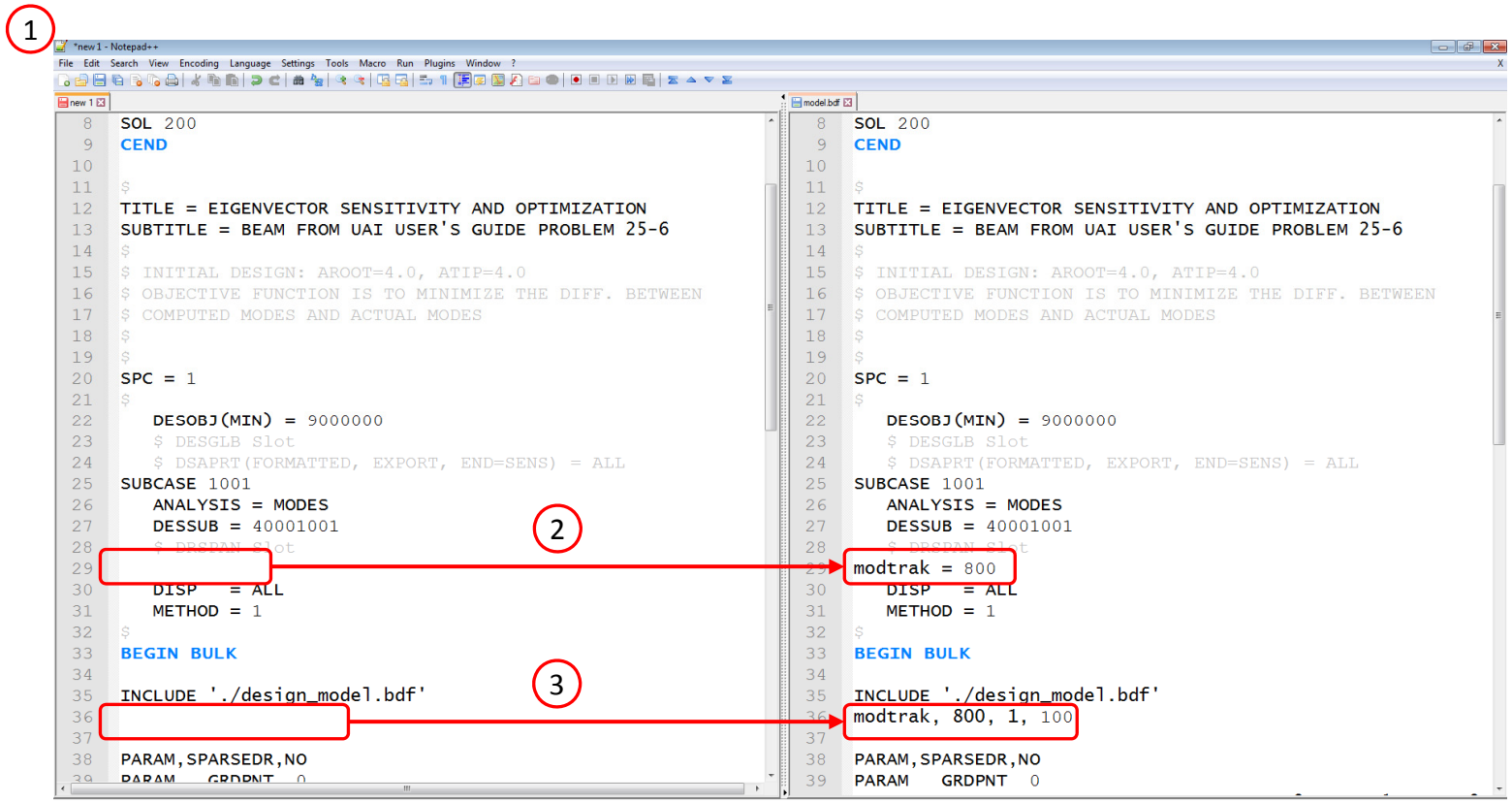
- Always extract the contents of the ZIP file to a new, empty folder.



# Manually Edit the BDF File

1. Open the model.bdf file in notepad
2. To the Case Control Section, add *MODTRAK = 800*
3. To the Bulk Data Section, add
   - *MODTRAK, 800, 1, 100*
4. Save the .bdf file

- Mode numbers are numbered in order of increasing frequency. As an example, if Mode 2 becomes Mode 5, the mode shape is preserved but the frequency is increased, but the constraint is configured for Mode 2. To ensure the constraint is applied to the new Mode 5, Mode Tracking is employed.



# 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

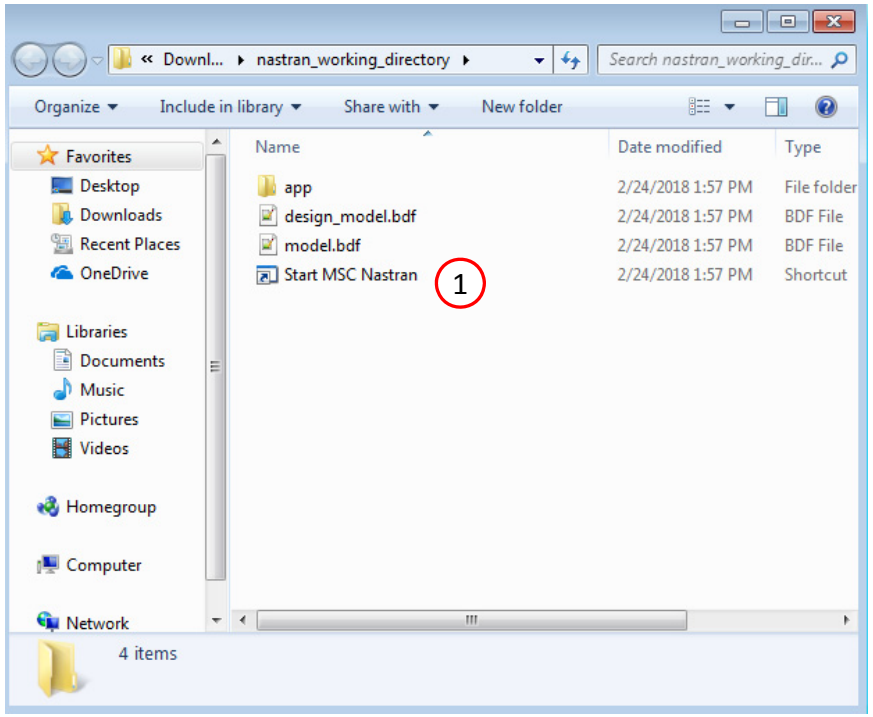
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows: 1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the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

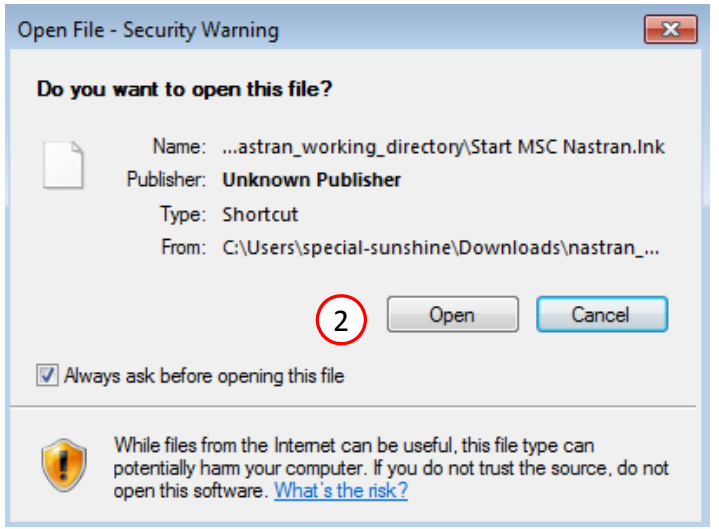
**Using Linux?**

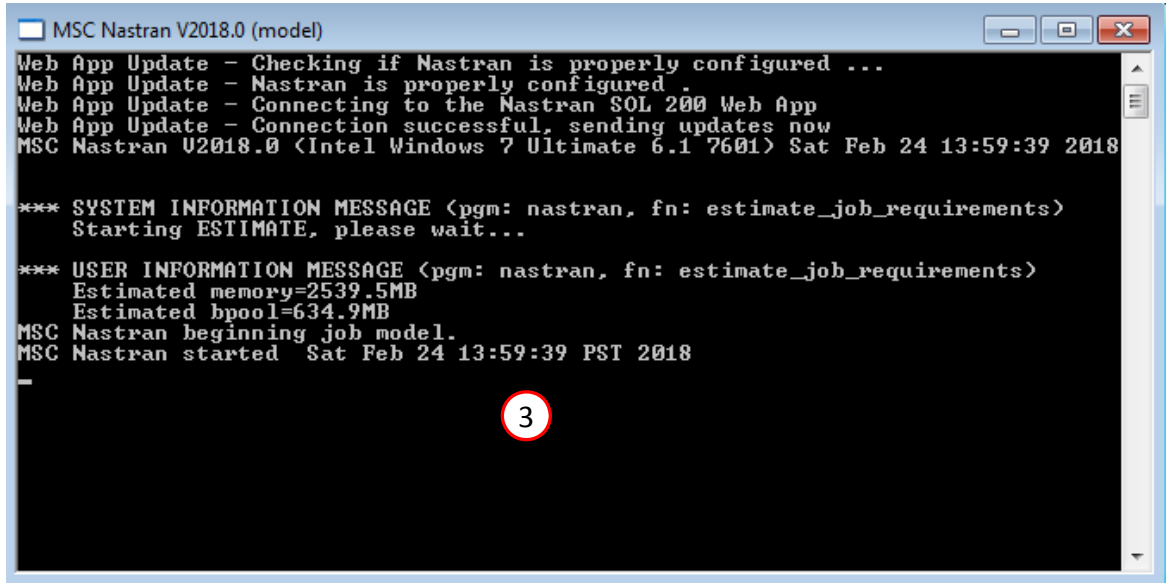
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
cd ./nastran_working_directory
3) Use this command to start the process
./Start_MSC_Nastran.sh

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



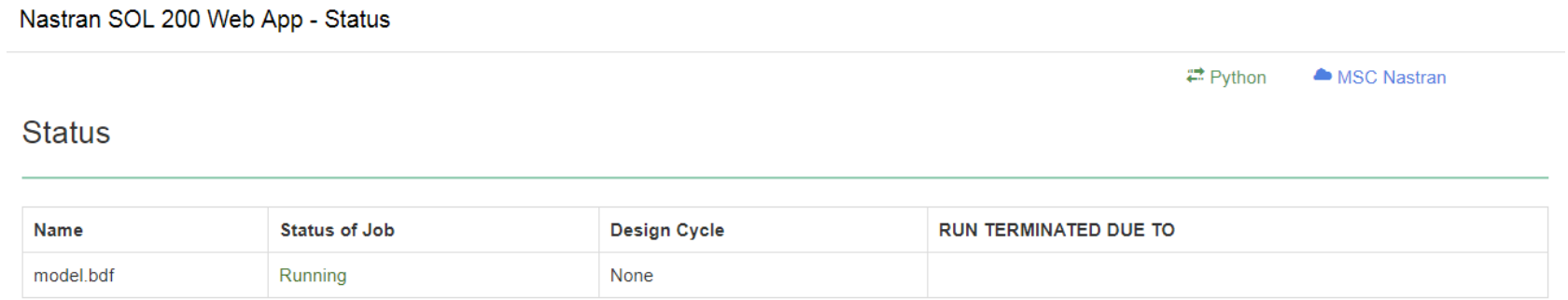



# Status

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.



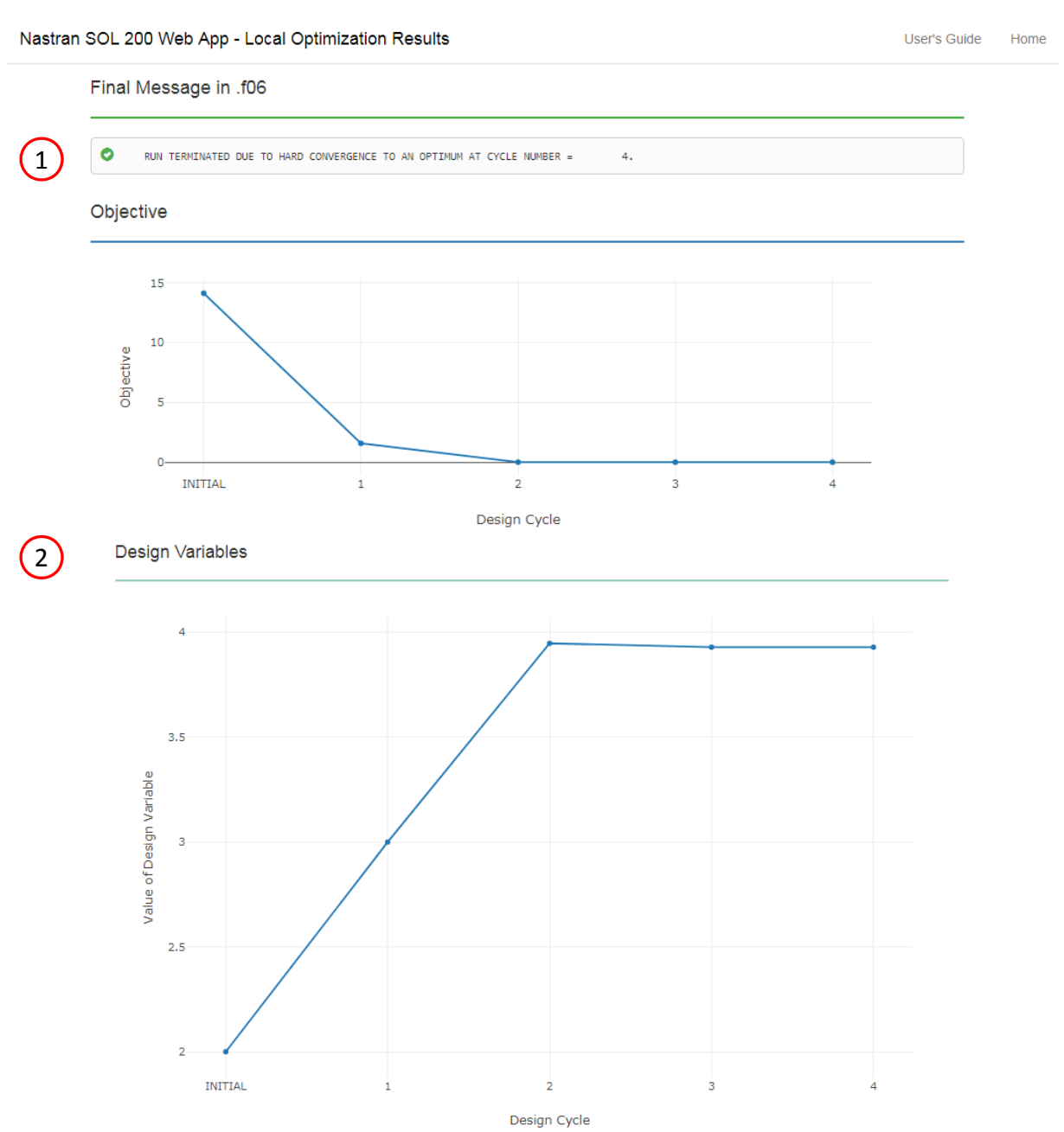
# Review Optimization Results

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.

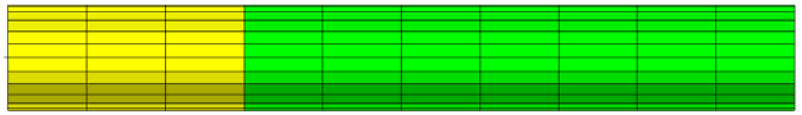
Nastran SOL 200 Web App - Responses - Model Matching

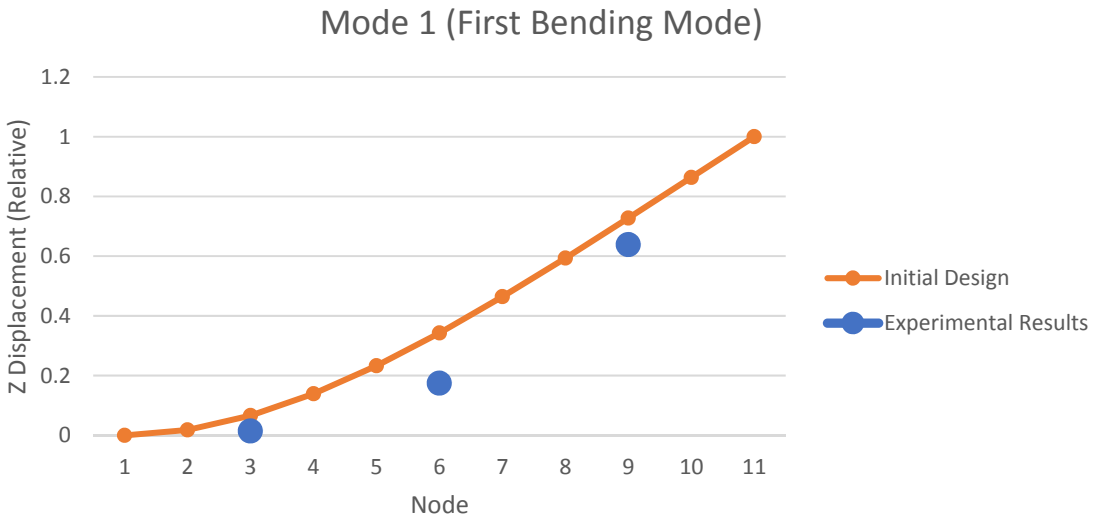
1 Model Matching Bar Charts


| 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 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 |

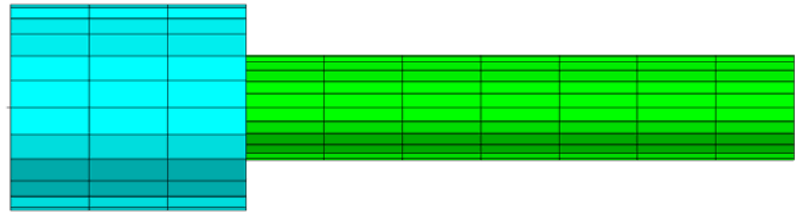
# Results

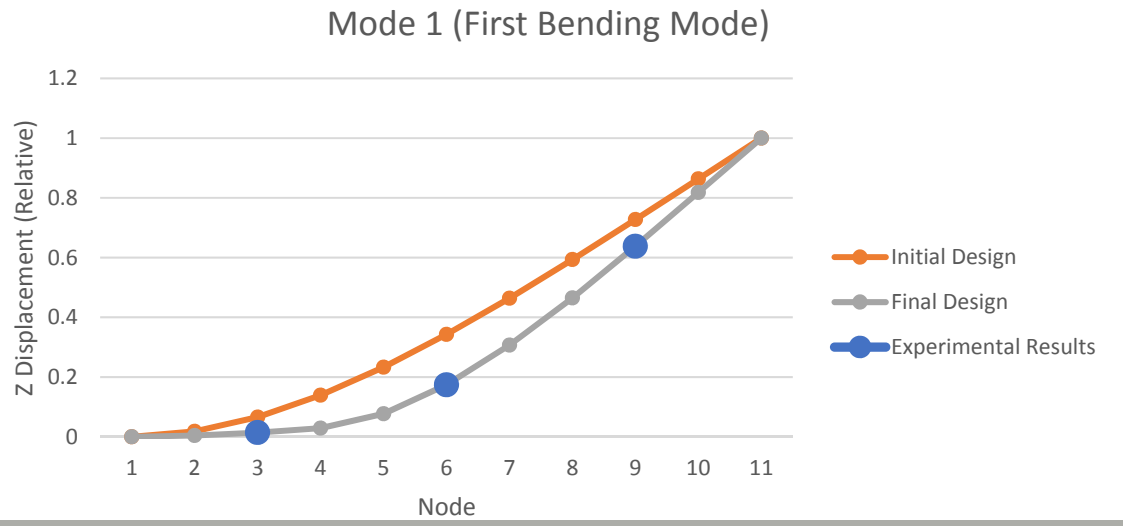
## Before Optimization
Radius: 2 in





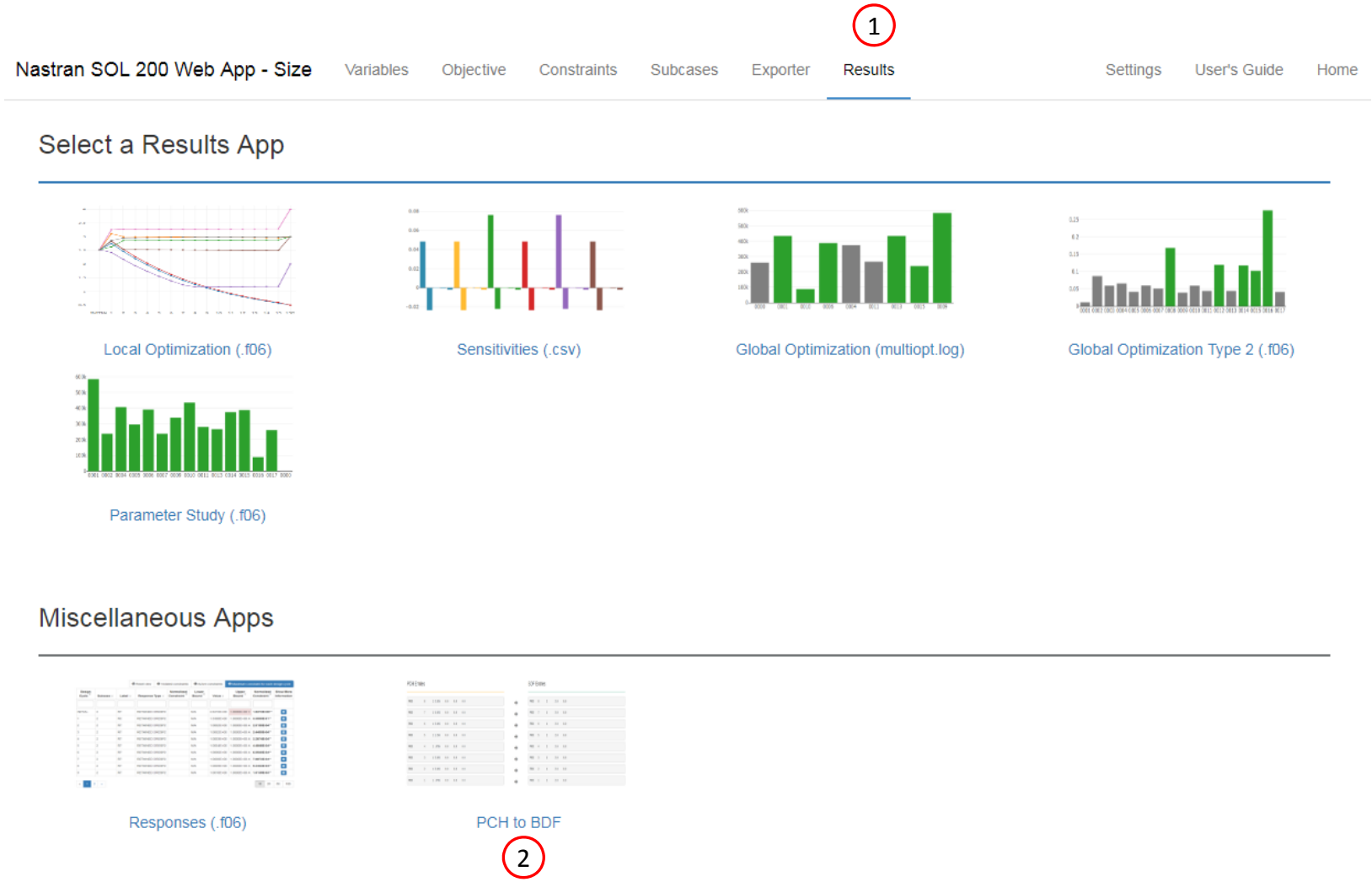

## After Optimization
- Radius 3.93 in





# Update the Original Model

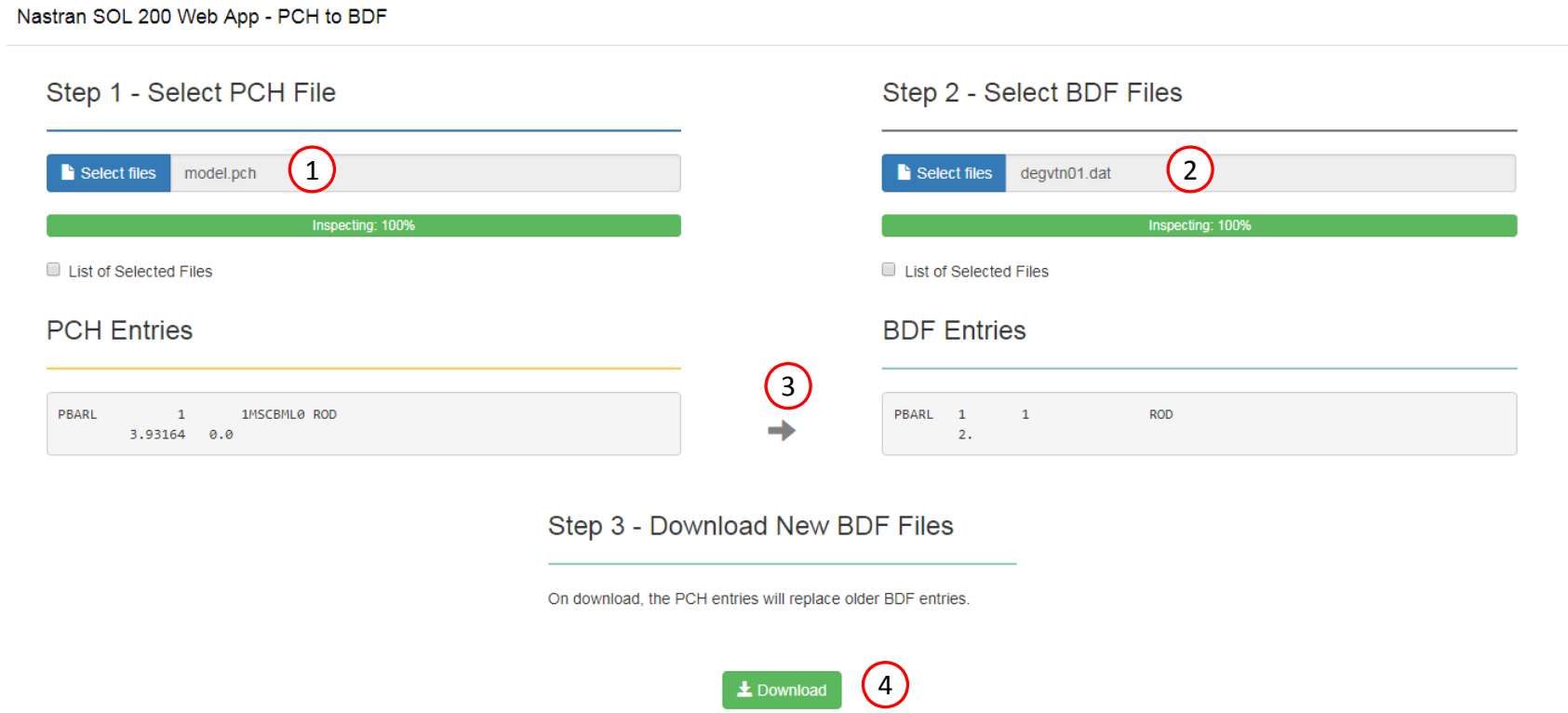
1. Click Results
2. Click PCH to BDF



# Update the Original Model

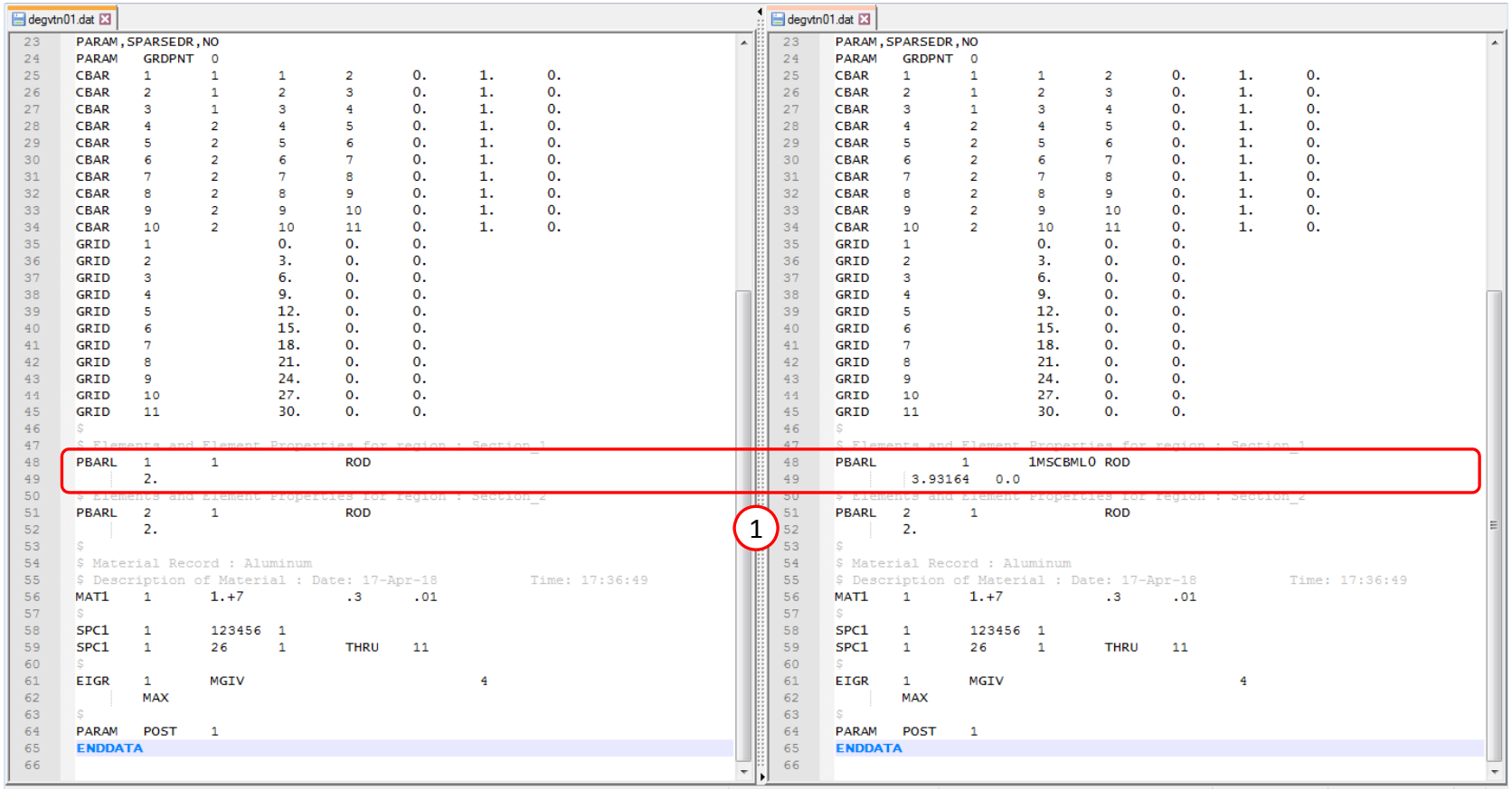
The original .bdf/.dat file has old information about the properties. The properties will be updated.

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




Original BDF/DAT File

Downloaded BDF/DAT File

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