

# Workshop - Global Optimization of a Composite Laminate

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AN MSC NASTRAN SOL 200 TUTORIAL

# Global Optimization

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This example is a continuation of a previous example titled: Workshop - Automated Optimization of a Composite Laminate

# Optimization Problem Statement

## Design Variables

x1: T of lamina 1 of PCOMP 1  
x2: T of lamina 2  
x3: T of lamina 3  
x4: T of lamina 4  
x5: T of lamina 5  
x6: T of lamina 6  
x7: T of lamina 7  
x8: T of lamina 8

$$.001 < x_i$$

x9: Orientation of lamina 1 of PCOMP 1  
x10: Orientation of lamina 2  
x11: Orientation of lamina 3  
x12: Orientation of lamina 4  
x13: Orientation of lamina 5  
x14: Orientation of lamina 6  
x15: Orientation of lamina 7  
x16: Orientation of lamina 8

y1: Thickness of layers  
y2: Angle of layers (85)  
y3: Angle of layers (-85)

$$.001 < y_1 < 10.$$

$$-90. < y_2 < 90.$$

$$-90. < y_3 < 90.$$

### Variable Linking

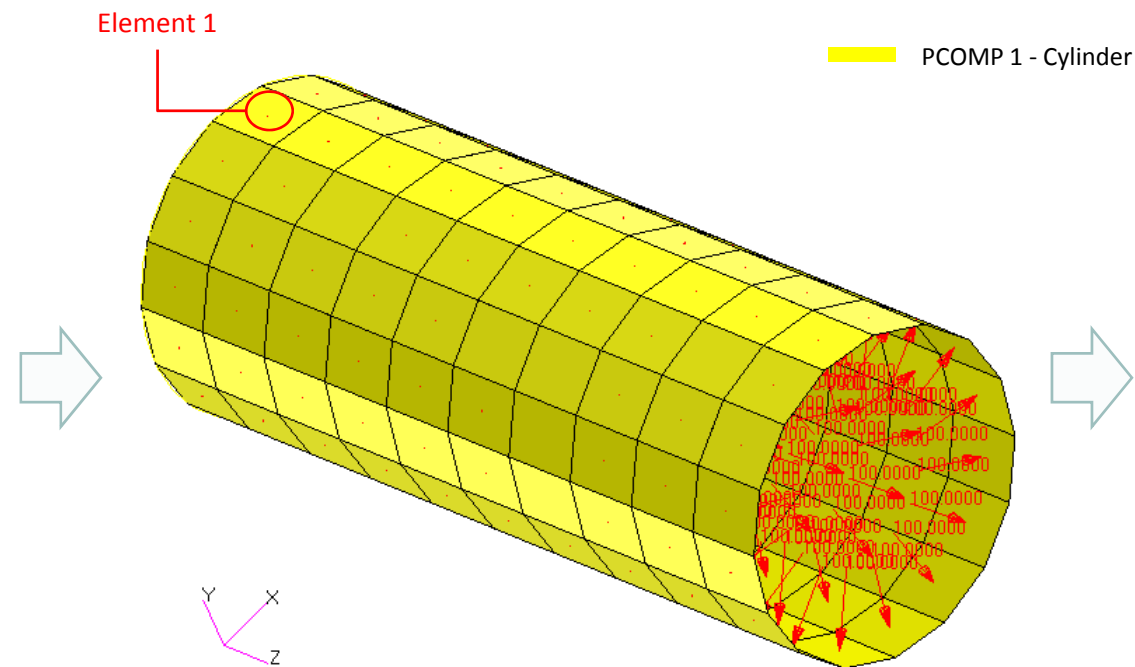
$$x_1, x_2, x_3, \dots, x_8 = y_1$$

$$x_9, x_{15} = y_2$$

$$x_{10}, x_{16} = -1.0 * y_2$$

$$x_{11}, x_{13} = y_3$$

$$x_{12}, x_{14} = -1.0 * y_3$$



## Design Objective

r0: Minimize weight

## Design Constraints

r1: Failure index of lamina 1 of element 1

...

r8: Failure index of lamina 8 of element 1

$$r_1, \dots, r_8 < .9$$

# Contact me

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

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# Tutorial

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# Tutorial Overview

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1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
  - Configure Global Optimization
  - Perform optimization with Nastran SOL 200

# SOL 200 Web App Capabilities

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

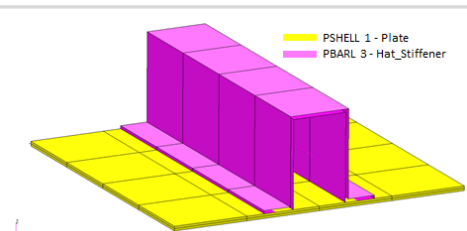
## Compatibility

- 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.

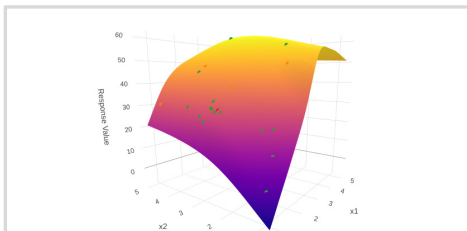
## Web Apps

## Benefits

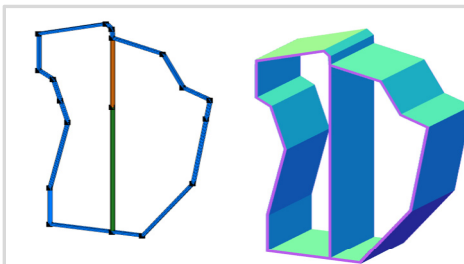
- REAL TIME error detection. 200+ error validations.
- REAL TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials



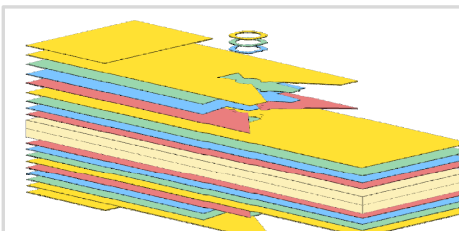
**Web Apps for MSC Nastran SOL 200**  
Pre/post for MSC Nastran SOL 200.  
Support for size, topology, topometry, topography, multi-model optimization.



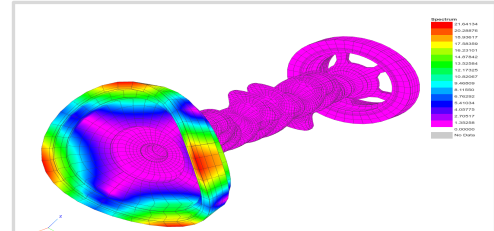
**Machine Learning Web App**  
Bayesian Optimization for nonlinear response optimization (SOL 400)



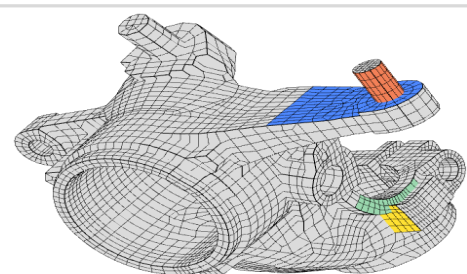
**PBMSECT Web App**  
Generate PBMSECT and PBRSECT entries graphically



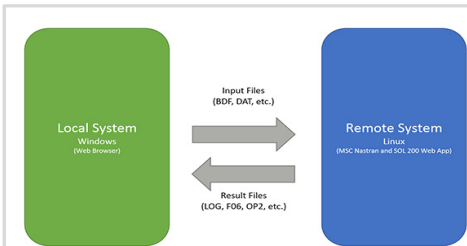
**Ply Shape Optimization Web App**  
Optimize composite ply drop-off locations, and generate new PCOMPG entries



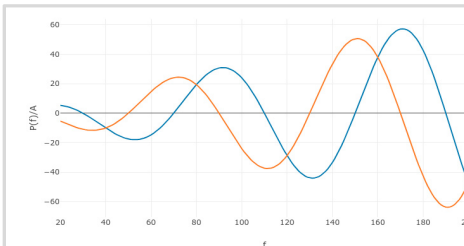
**Post-processor Web App**  
View MSC Nastran results in a web browser on Windows and Linux



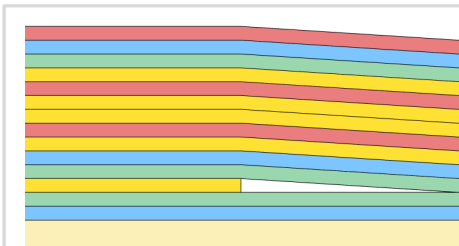
**Shape Optimization Web App**  
Use a web application to configure and perform shape optimization.



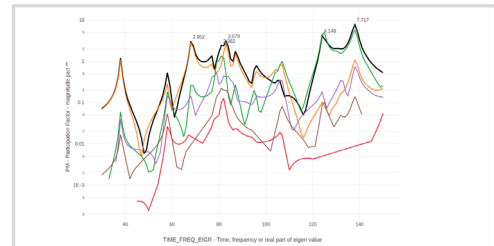
**Remote Execution Web App**  
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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



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

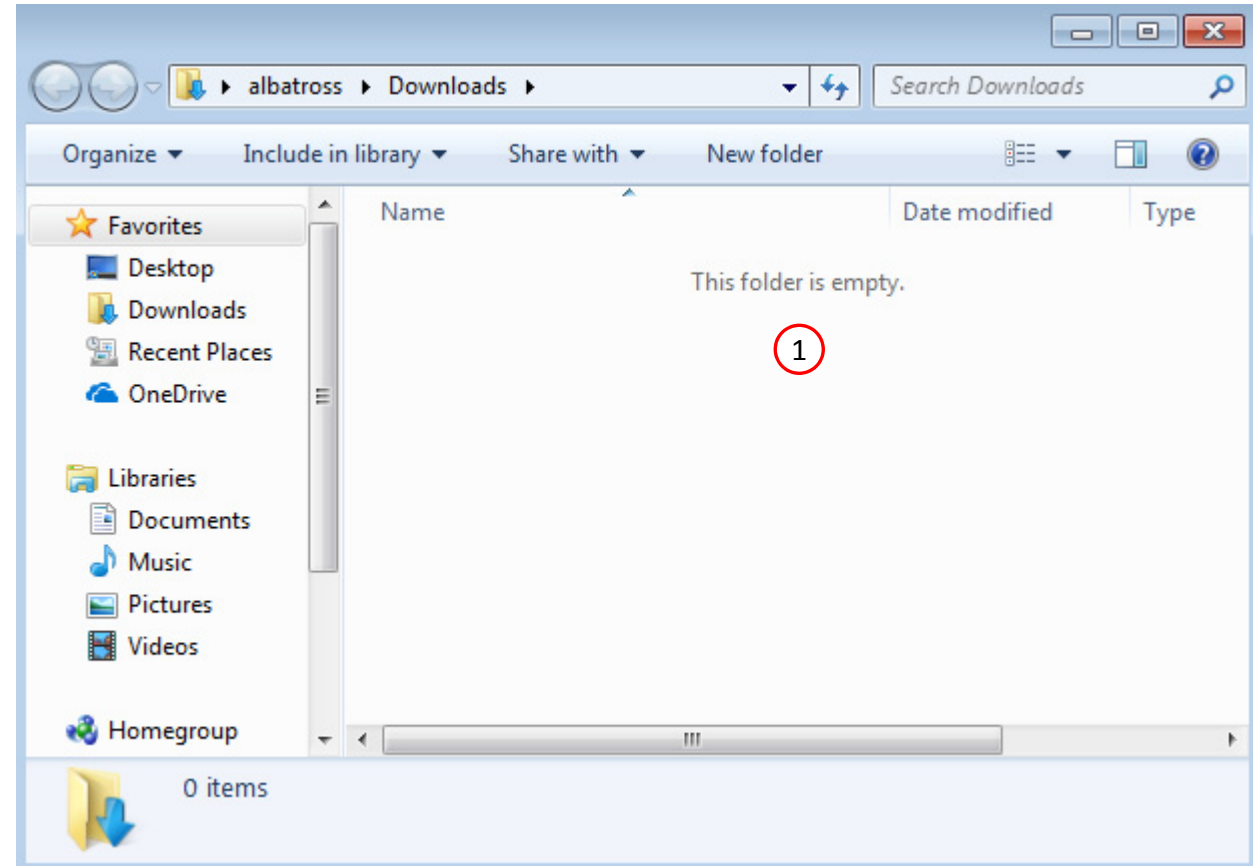


**HDF5 Explorer Web App**  
Create graphs (XY plots) using data from the H5 file

# 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

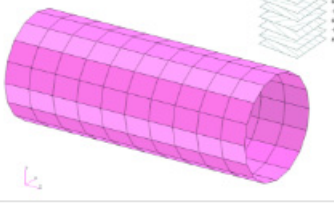
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.



# 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.



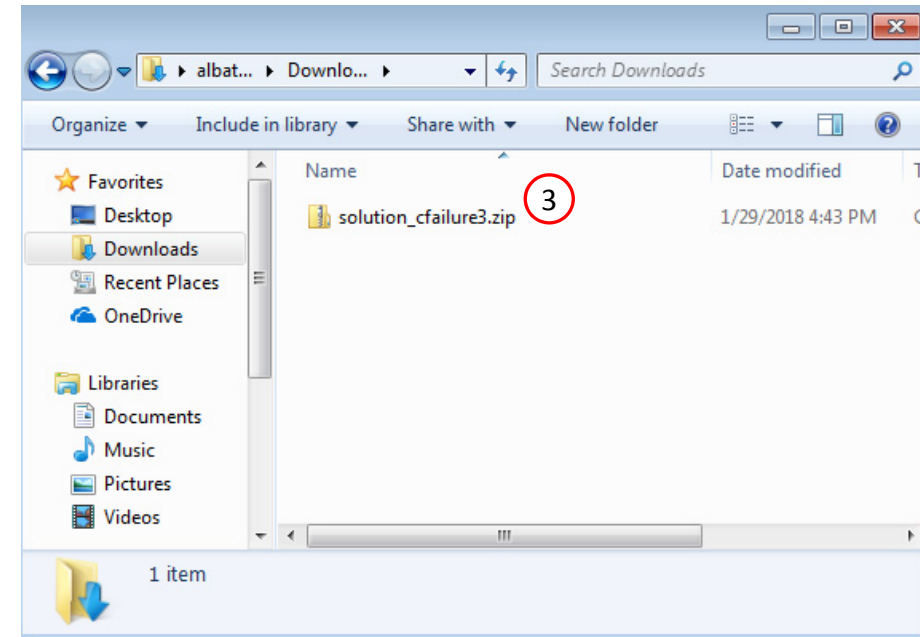
## 1 Global Optimization

This examples demonstrates the procedure of performing a Global Optimization with MSC Nastran SOL 200.

Often, optimization problems have multiple local minimas, or maximas, when starting from different initial design variables. In order to find the global optimum, multiple local optimizations must be performed, then the best of the local optimizations is taken to be global optimum. This process can be performed with the Global Optimization capability available in MSC Nastran SOL 200.

Starting BDF Files: [Link](#)

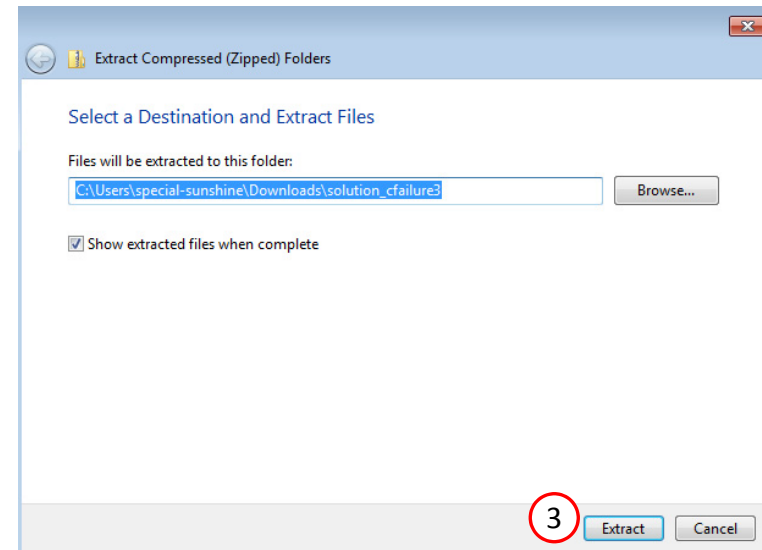
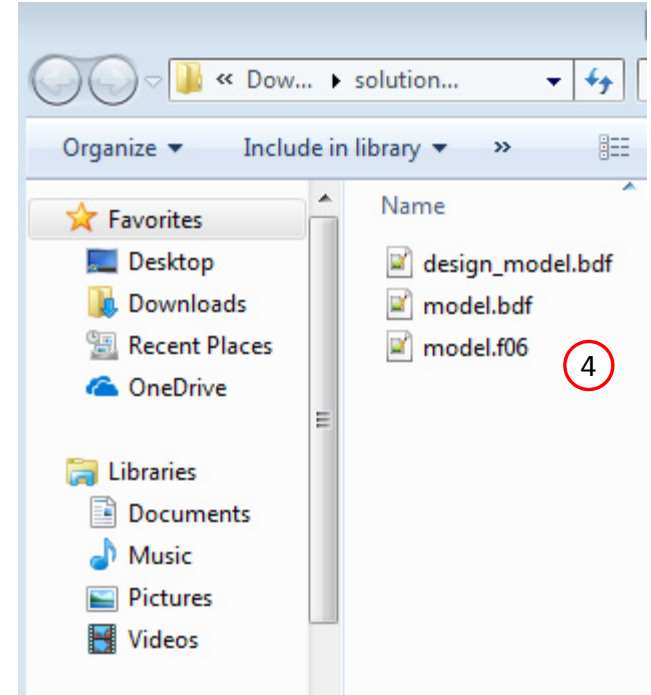
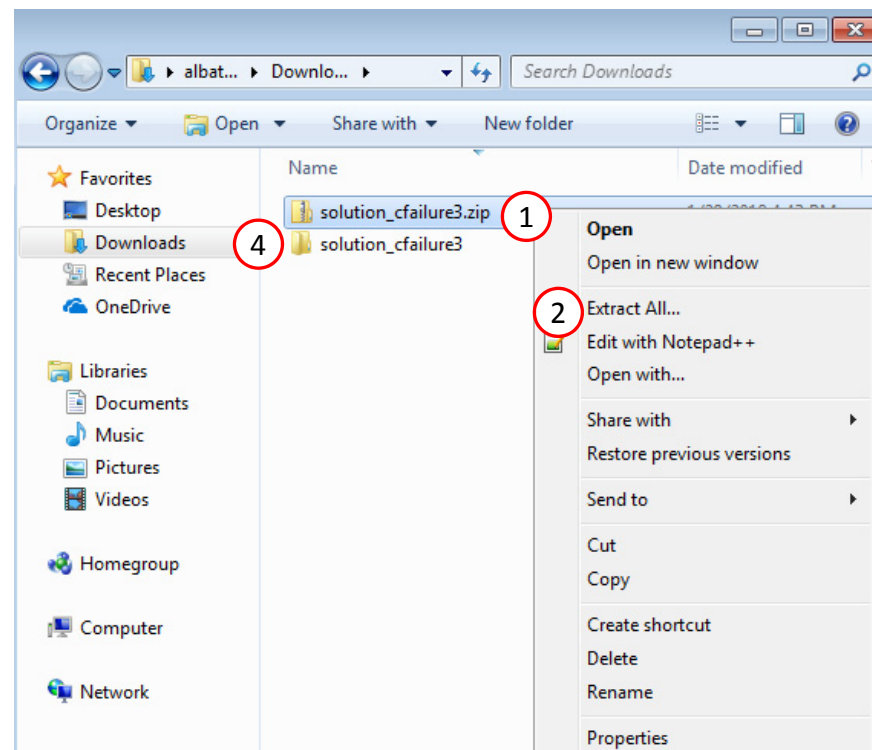
Solution BDF Files: [Link](#)



# Obtain Starting Files

1. Right click on the zip file
2. Select Extract All...
3. Click Extract
4. The starting files are now available in a folder

- This example is using a previously created design model. The design model is a model that has been converted to SOL 200 and contains bulk data entries describing the optimization problem statement, e.g. variables, objective and constraints.



# 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 model.bdf and design\_model.bdf
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 blue bar and indicates '2 files selected'. Below it, a green progress bar shows 'Inspecting: 100%'. Step 2, '2. Upload files', is highlighted with a green bar. Below it, another green progress bar shows 'Uploading: 100 %'. At the bottom, there is a checkbox labeled 'List of Selected Files' which is currently unchecked.

1. Select files 2 files selected

Inspecting: 100%

2. Upload files

Uploading: 100 %

☐ List of Selected Files





# 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”

SOL 200 Web App - Optimization Upload Variables Objective Constraints Subcases **1** Exporter Results Settings Match Other User's Guide Home

BDF Output - Model

```
$ NASTRAN input file created by the Patran 2013.0.2 input file
$ translator on February 08, 2017 at 15:12:27.
$ Direct Text Input for Nastran System Cell Section
$ Direct Text Input for File Management Section
$ Direct Text Input for Executive Control
$ Linear Static Analysis, Database
SOL 200
CEND

$ Direct Text Input for Global Case Control Data
TITLE = MSC.Nastran job created on 08-Feb-17 at 14:20:39
ECHO = NONE
DESOBJ(MIN) = 8000000
$ DESGLB $!ot
$ DSAPRT(FORMATTED, EXPORT, END+SENS) = ALL
SUBCASE 1
ANALYSIS = STATICS
DESSUB = +0000001
$ DRSPAN $!ot
SUBTITLE=Default
SPC = 2
LOAD = 2
DISPLACEMENT(SORT1,REAL)=ALL
SPCFORCES(SORT1,REAL)=ALL
STRESS(SORT1,REAL,VONMISES,CENTER)=ALL
$ Direct Text Input for this Subcase
BEGIN BULK
INCLUDE './design model.bdf'
```

BDF Output - Design Model

```
$*****
$*
$*          Design Model
$*
$*****
$
$          Design Variables - Type 1
$-----
$
$
DVPREL1 1000001 PCOHP 1 T1
100001 1.0
DVPREL1 1000002 PCOHP 1 T2
100002 1.0
DVPREL1 1000003 PCOHP 1 T3
100003 1.0
DVPREL1 1000004 PCOHP 1 T4
100004 1.0
DVPREL1 1000005 PCOHP 1 T5
100005 1.0
DVPREL1 1000006 PCOHP 1 T6
100006 1.0
DVPREL1 1000007 PCOHP 1 T7
100007 1.0
DVPREL1 1000008 PCOHP 1 T8
100008 1.0
DVPREL1 1000009 PCOHP 1 THETA1
100009 1.0
DVPREL1 1000010 PCOHP 1 THETA2
100010 1.0
DVPREL1 1000011 PCOHP 1 THETA3
100011 1.0
DVPREL1 1000012 PCOHP 1 THETA4
100012 1.0
DVPREL1 1000013 PCOHP 1 THETA5
100013 1.0
DVPREL1 1000014 PCOHP 1 THETA6
100014 1.0
DVPREL1 1000015 PCOHP 1 THETA7
100015 1.0
DVPREL1 1000016 PCOHP 1 THETA8
100016 1.0
```

Download BDF Files

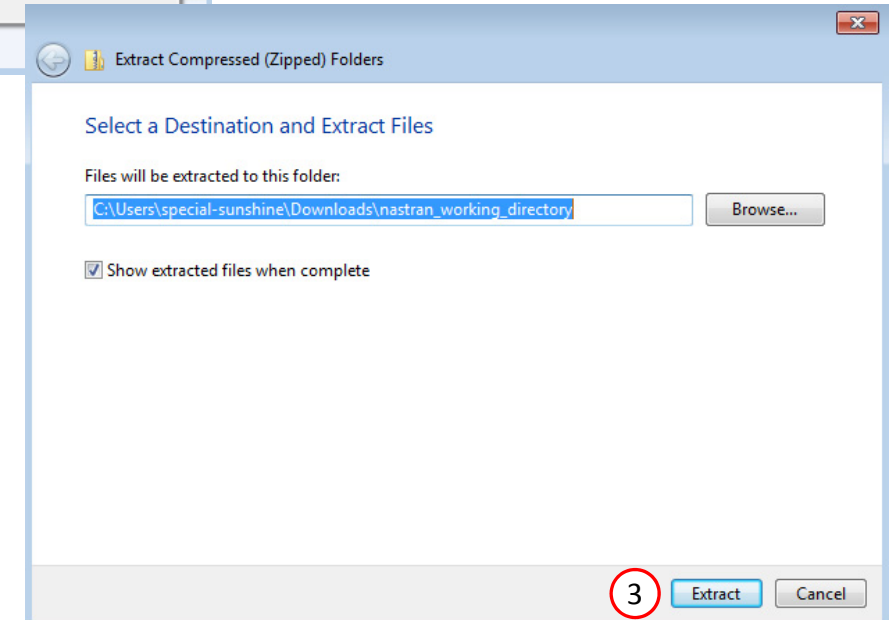
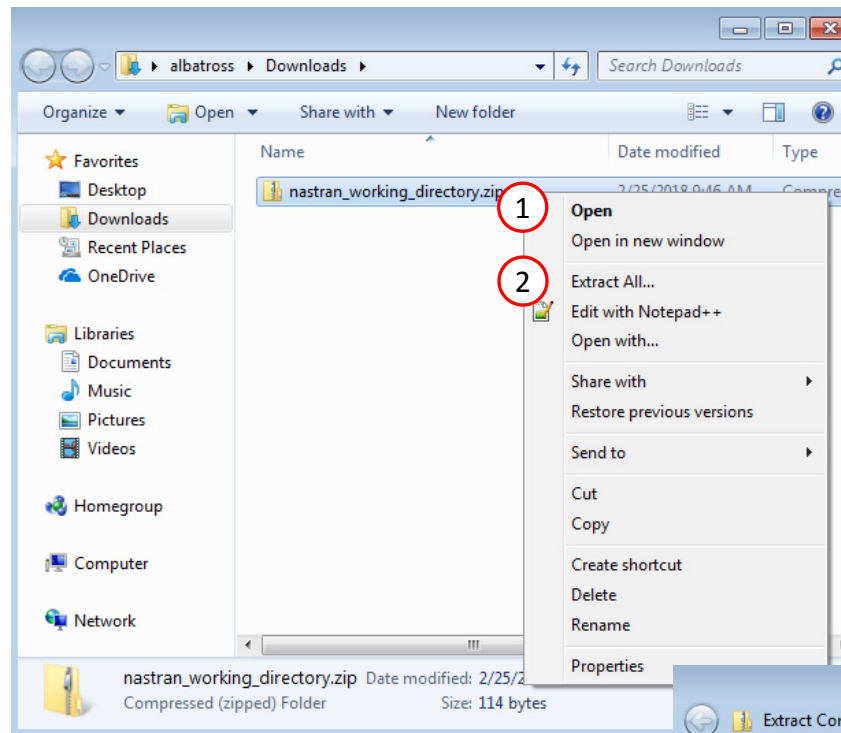
[Download BDF Files](#) **2**

Developed by The Engineering Lab

# 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.





# 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.

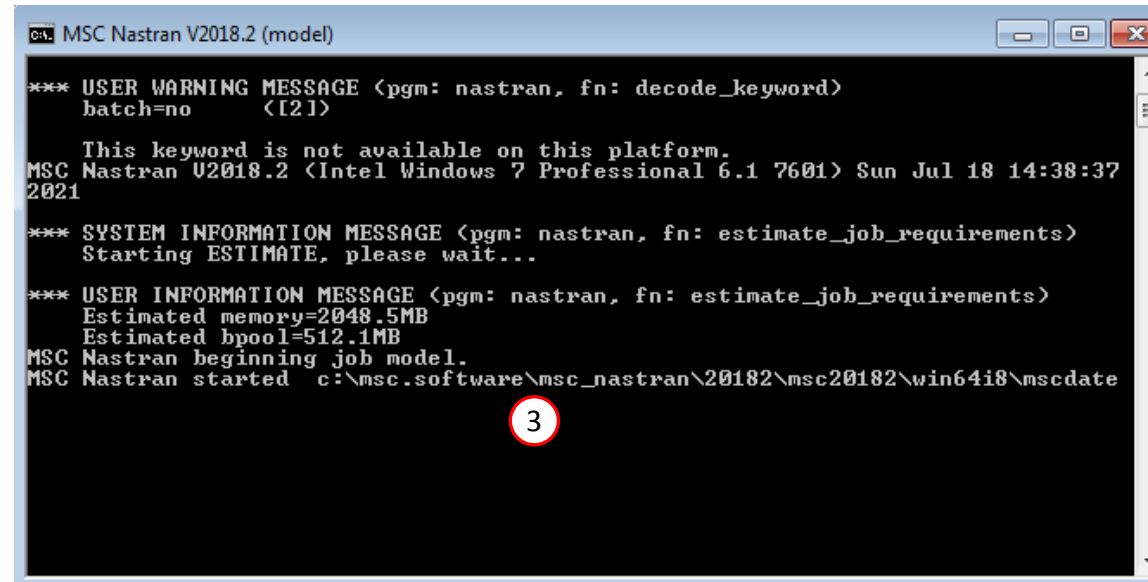
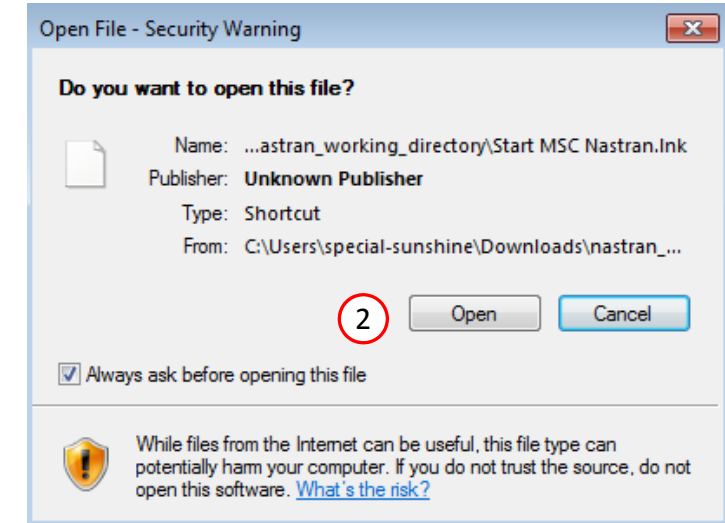
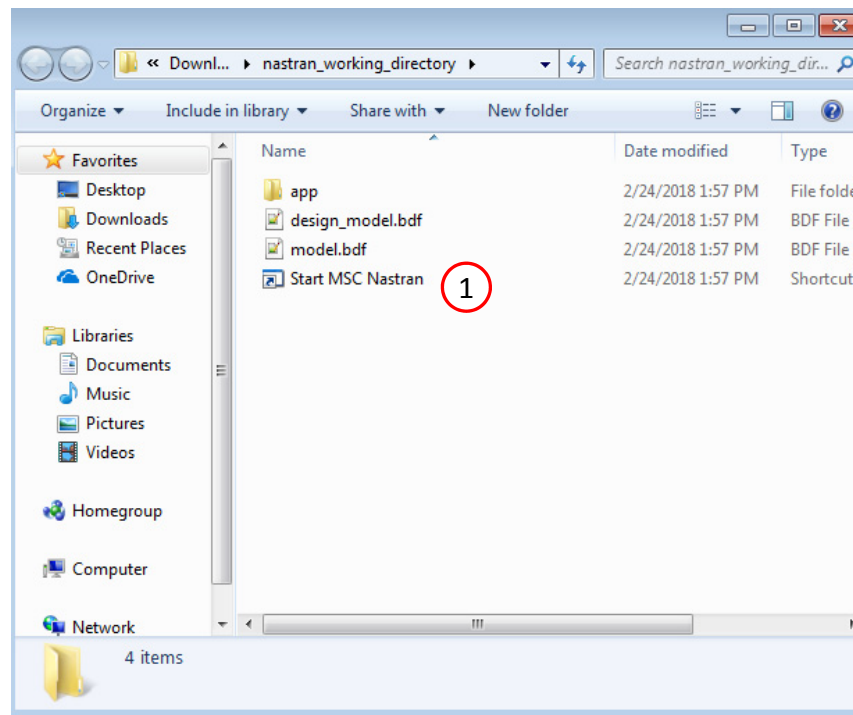
## Using Linux?

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 successfully complete, the results will be automatically uploaded.

For each sample the objective, normalized constraints, and design variables are displayed in a bar chart and table.

1. The select box can be used to display specific samples.
2. The Final Message found in the multipt.log file provides information regarding the global minimum or maximum

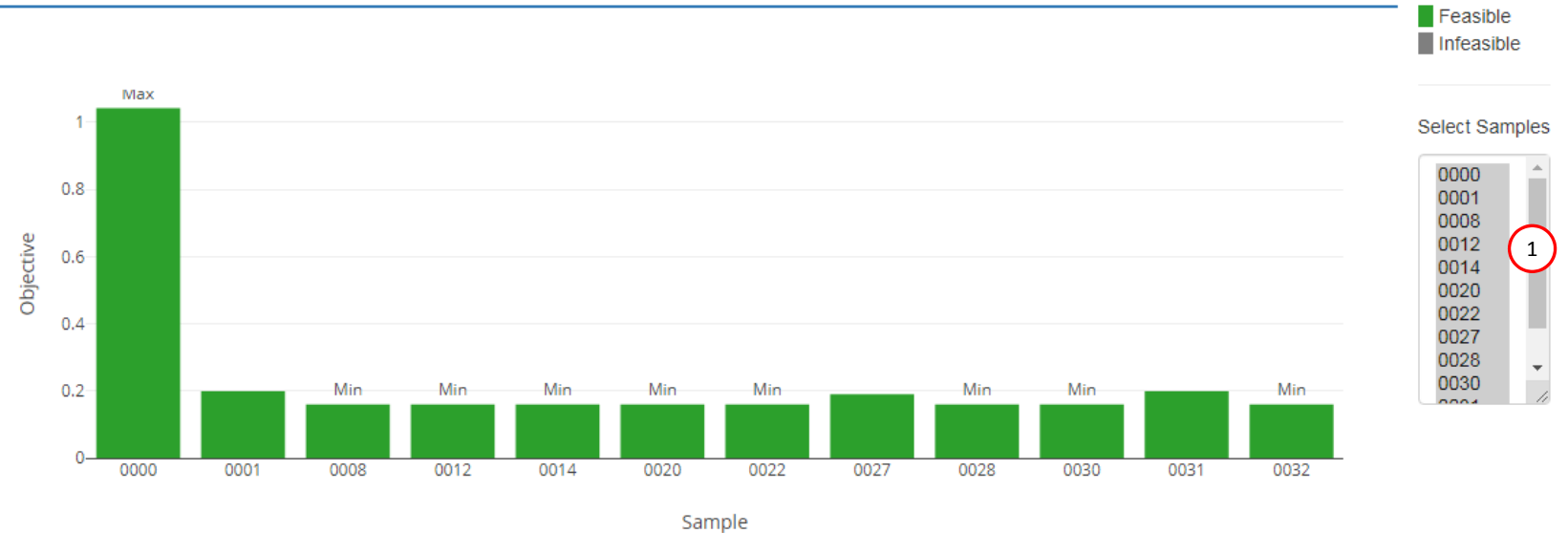
- The Global Optimization has performed multiple local optimizations and are labeled by different Sample numbers. Out of all the local optimizations performed or samples, the global optimum is the better of all. The sample that is the global optimum is reported in the section Final Message in multipt.log. The sample and its respective objective and variables are listed in the bar chart and table.

## Final Message in multipt.log

THE GLOBAL SOLUTION IS: LOCAL OPTIMIZATION SAMPLE # 32  
 OBJECTIVE = 1.5982E-01,  
 MAXIMUM CONSTRAINT VALUE = -2.7357E-01 (A FEASIBLE SOLUTION).

2

## Objective for Each Sample



Data for Each Sample

Item	Sample 0000	Sample 0001	Sample 0008	Sample 0012	Sample 0014	Sample 0020	Sample 0022	Sample 0027	Sample 0028
Extrema (Max/Min)	Max		Min	Min	Min	Min	Min		Min
Objective	1.0421E+00	1.9938E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.5982E-01	1.8992E-01	1.5982E-01
Normalized Constraint	-1.8745E-04	-3.6671E-02	-2.7357E-01	-1.2455E-01	-1.2455E-01	-1.2455E-01	-1.2455E-01	-2.8497E-01	-1.2455E-01
Y1	6.5204E-03	1.2475E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.0000E-03	1.1884E-03	1.0000E-03
Y2	9.0000E+01	5.0000E+00	0.0000E+00	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	-5.0000E+00	0.0000E+00
Y3	0.0000E+00	1.0000E+01	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	0.0000E+00	5.0000E+00	5.0000E+00

End of Tutorial