Workshop - MSC Nastran Topometry Optimization of a Composite Panel

AN MSC NASTRAN SOL 200 TUTORIAL

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



Goal: Use Nastran SOL 200 Optimization

Use Topometry optimization to determine ply shapes





Goal: Use Nastran SOL 200 Optimization

Use Topometry optimization to determine optimal ply shapes



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HEXAGON Technology Partner

Goal: Use Nastran SOL 200 Optimization

Before Optimization

• Panel of initial layup

After Optimization

- Panel of updated layups
- The weight is reduced





Details of the structural model



Panel: 16in. x 10in. Layup: [80/-65/80/-65]_s

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



Optimization Problem Statement





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



Before Continuing

Consider the New Composite Laminate Optimization Tutorials – Composite Coupon

Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	 Composite Coupon – Phase A – Determination of the optimal 0° direction of a composite The goal of this 5-phase tutorial series is to optimize a composite coupon, with a core, and produce a lightweight composite that satisfies failure index constraints. The optimal ply shapes (ply drop-offs) and ply numbers are determined for 0°, ±45°, and 90° plies. A stacking sequence optimization is performed to satisfy manufacturing requirements. One important part of optimizing composites is visualizing the composite plies. This tutorial series also demonstrates the visualization of ply drop-offs, tapered plies and core layers. This first phase involves determining the optimal 0° direction of a composite. It is best practice to align the 0° plies in the direction of the load. Not doing so will more than likely produce a suboptimal composite that is heavier than necessary. This tutorial demonstrates the use of MSC Nastran's optimizer to determine the optimal 0° direction of a composite. An optimization is performed to maximize the stiffness of the composite for multiple load cases and while varying the angle of the 0° plies. Ultimately, the best 0° direction is determined. This is the first phase in a 5-phase tutorial series. 	Link	Link
	Composite Coupon – Phase B – Baseline Ply Number Optimization This tutorial demonstrates how to configure a basic ply number optimization of continuous plies that span the entire model. The goal of this tutorial is to demonstrate basic actions such as creating variables, a weight objective and constraints on failure index. The results of this ply number optimization serve as a baseline for future comparisons. In a subsequent tutorial, the ply shapes will be optimized to minimize weight. This is the second phase in a 5-phase tutorial series.	<u>Link</u>	<u>Link</u>
	Composite Coupon – Phase C – Data Preparation for Ply Shape Optimization This tutorial is a guide to preparing data for ply shape optimization in a subsequent tutorial. The maximum failure index values of the outer plies of the composite are determined and saved to specially formatted PLY000i files. The PLY000i files will be used to construct optimal ply shapes in a subsequent tutorial. This is the third phase in a 5-phase tutorial series.	<u>Link</u>	<u>Link</u>
s? Email	christian@the-engineering-lab.com	8	

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Before Continuing

Consider the New Composite Laminate Optimization Tutorials – Composite Coupon, Continued

Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	Composite Coupon – Phase D – Ply Shape and Ply Number Optimization This tutorial details the process to build optimal ply shapes and perform a ply number optimization. The optimal ply shapes are constructed to follow the contours of the failure indices. The ply number optimization involves minimizing weight and constraining the failure indices of plies. The PLY000i files and BDF files from the previous tutorial, phase C, are used in this tutorial. This is the fourth phase in a 5-phase tutorial series.	<u>Link</u>	<u>Link</u>
Before	Composite Coupon – Phase E – Stacking Sequence Optimization This tutorial involves performing a stacking sequence optimization and is a continuation of the previous tutorial, phase D. A final statics analysis is performed to confirm the optimized composite satisfies failure index constraints. This is the fifth phase in a 5-phase tutorial series.	<u>Link</u>	<u>Link</u>



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Consider the New Composite Laminate Optimization Tutorials – Sandwich Composite Panel

Visit the User's Guide to access the newest tutorials.

	Title and Description	PDF Tutorial	YouTube Tutorial
	Sandwich Composite Panel – Phase B – Baseline Core Thickness OptimizationThe goal of this 3-phase tutorial series is to optimize a curved composite panel, with a core, and produce a lightweight composite that satisfies constraints on the buckling load factor. This tutorial series focuses exclusively on optimizing the thickness of the core. The methods detailed in the tutorial series are applicable to both foam and honeycomb cores.This tutorial demonstrates how to configure a basic core thickness optimization where the core has a constant thickness throughout the entire model. The goal of this tutorial is to demonstrate basic actions such as creating variables, a weight objective and constraints on the buckling load factor. The results of this core thickness optimization serve as a baseline for future comparisons. In a subsequent 	<u>Link</u>	<u>Link</u>
	Sandwich Composite Panel – Phase C – Topometry Optimization to Determine Optimal Core Shape This tutorial is a guide to preparing data for core shape and core thickness optimization in a subsequent tutorial. A topometry optimization is performed in this tutorial to determine the ideal thickness distribution of the core throughout the entire composite panel while satisfying constraints on the buckling load factor and minimizing weight. The results of a topometry optimization are contained in the PLY000i files and will be used to construct optimal core shapes in a subsequent tutorial. This is the second phase in a 3-phase tutorial series.	<u>Link</u>	<u>Link</u>
	Sandwich Composite Panel – Phase D – Core Shape and Core Thickness Optimization This tutorial details the process to build optimal core shapes and perform a core thickness optimization. The optimal core shapes are constructed to follow the contours of thickness results generated by a topometry optimization. The core thickness optimization involves minimizing weight and constraining the buckling load factor. The PLY000i files and BDF files from the previous tutorial, phase C, are used in this tutorial. Comparisons are made between this optimization in phase D and the baseline optimization performed in phase B. This is the third phase in a 3-phase tutorial series.	<u>Link</u>	<u>Link</u>
Questions? Email	christian@the-engineering-lab.com	10	

Tutorial

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



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 Regions/Variables
 - Design Objective
 - Design Constraints
 - Perform optimization with Nastran SOL 200
- 3. Review optimization results
 - .f06
 - Topometry Optimization and Structural Results

Special Topics Covered

Linked Properties in Topometry Optimization – When configuring a size optimization, there is an option to link variables, i.e. one variable is dependent on the change of another variable. A similar option exists for the thickness properties on the PCOMP entry, enabling users to link ply thicknesses of a composite laminate during a topometry optimization.



SOL 200 Web App Capabilities

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.

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

Benefits

entries.

- REAL TIME error detection. 200+
- error validations.
- REALT TIME creation of bulk data
- 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.



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



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



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



PBMSECT Web App Generate PBMSECT and PBRSECT entries graphically



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



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



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



browser on Windows and Linux



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



Before Starting

 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.





The Engineering Lab

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.

Select a web app to begin Before After Optimization for SOL 200 Multi Model Optimization Machine Learning | Parameter HDF5 Explorer Viewer Study Tutorials and User's Guide (1)Full list of web apps

SOL 200 Web App

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





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.



MSC Nastran Topometry Optimization of a Composite Panel

This tutorial covers the use of Topometry Optimization to determine ply shapes.



(1)





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.



SOL 200 Web App

Select a web app to begin







Machine Learning | Parameter Study

Tutorials and User's Guide

Full list of web apps



HDF5 Explorer



Viewer

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



Upload BDF Files

- Click 1. Select Files and select tomex500.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





Create Design Region

- 1. Click Topometry
- 2. In the search box, type 'thickness'
- 3. Click on the plus (+) icons to set the thickness (Ti) of Plies 1-4 as Design Regions
- 4. Scroll to the section titled Step 2 Adjust TOMVAR entries
- 5. The new Design Region is added to the table, no further edit is necessary
- Suppose the goal is to vary the thickness. In traditional Size optimization, the thickness can be a set a single design variable. With Topometry optimization, when the design region is set, each element in the region is given its own independent thickness design variable.
- If PSHELL 1 has 500 elements associated and is configured as a design region, then there will be 500 design variables created.
- 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.

SOL 200 Web App - Optimization	Upload	Variables	Objective	Constraints	Subcases	Exporter	Results
Size Topology Topometry 1	ography						

Step 1 - Select design properties

+ Options

+ Options

(Create TOMVAR Property \$		Property Description \Leftrightarrow	Entry ≑	Entry ID 💠	ID		
		Search	thickness 2	Search	Search	Search		
	÷	T1	Thickness of ply	PCOMP	1	1.000		
(3		T2	Thickness of ply	PCOMP	1	1.000		
	•	ТЗ	Thickness of ply	PCOMP	1	1.000		
	•	Τ4	Thickness of ply	PCOMP	1	1.000		



X Delete Visible Rows

4 Step 2 - Adjust TOMVAR Entries

	Label ¢	Status ≑	Property 🌲	Property Description $\mbox{$$$$$$$$$$$$$$$$$}$	Entry \$	Entry ID 💠	$\underset{\oplus}{\text{Initial Value}}$	Lower Bound	Upper Bound	Allowed Discrete Values
	Search	Search	Search	Search	Search	Search	Search	Search	Search	Search
×	z1	0	T1	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
×	Z2	5 0	T2	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
×	z3	•	Т3	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'
×	Z4	0	Т4	Thickness of ply	PCOMP	1	1.000	.001	Upper	Examples: -2.0, 1.0, THRU, 10.0, B'



Create Design Region

- Scroll to the section titled Step 3 Optional – Create variable links for TOMVARs
- 2. Click 2 times on +Create DLINK
- 3. Create design variables links for the thickness of ply 1 and 3
 - 1. Dependent Design Variables: z3
 - 2. Equation: z1
- 4. Create design variables links for the thickness of ply 2 and 4
 - 1. Dependent Design Variables: z4
 - 2. Equation: z2
- It is important to verify the Equation is configured properly. For example, the variable z3 is initially equal to 1.0. When the Equation is configured, it should also produce an initial value of 1.0. The resulting value of the Equation is displayed on the column titled Value of Equation and can be used to validate the Equation is configured properly.



	Status 🌲	Dependent Design Variables ≑	Equation (Independent Design Variables) ≑	Value of Equation $\mbox{$\updownarrow$}$
	Search	Search	Search	Search
×	•	z3 (3.1)	z1 3.2	1.
×	0	z4 (4.1)	z2 4.2	1.



Create Design Objective

- 1. Click on Objective
- 2. Type 'comp' in the search box
- 3. Select the plus(+) icon for Compliance
- 4. The objective with label r0 is created. The objective is to minimize (MIN)
- The objective must always be a single scalar response. A response such as weight and volume are single responses and can be used as an objective. Other responses require special care when set as an objective. For example, if the objective is stress, only the stress of a single component, e.g. von Mises, of a single element, of a single load case may be used.

jeenve	Equation Objective			
Step	1 - Select an objective			
Select an	analysis type			
SOL 101	1 - Statics			
Select a r	esponse			
Select a r	Response Description \$\overline{2}\$			Response Type ≑
Select a r	Response Search		comp 2	Response Type 🗢
Select a r	Response Description \$ Search Compliance (Product of displacement and the applied load)	c	comp 2	Response Type 🗢

Step 2 - Adjust objective

+ Options

	Label	Status	Response Type	Maximize or Minimize	Property Type	ΑΤΤΑ	ATTB	ATTI
×	rO	0	сомр (4	MIN ~				



Create Design Constraints

- 1. Click Constraints
- 2. Click on the plus (+) icon for Weight
- B. Configure the following for r1:
 - Upper Allowed Limit: 38.0

 The constraints are defined normally as would be done in a size optimization.

SOL 200 Web App - Optimization	Upload	Variables	Objective	Constraints	Subcases	Exporter	Results
Constraints Equation Constraints							
Step 1 - Select constr	aints						



Select a response

		Response Description ≑	Response Type 💠
		Search	Search
2) 🗗	Weight	WEIGHT
	÷	Volume	VOLUME
	÷	Displacement	DISP
	+	Strain	STRAIN
	+	Element Strain Energy	ESE

« 1 2 3 4 5 »

Step 2 - Adjust constraints

+ Options

	Label	Status ≑	Response Type [⊕]	Property Type	ATTA 🗢	ATTB \$	ATTi ≑	Lower Allowed Limit	Upper Allowed Limit
	St	Sear	Search	Search	Search	Search	Search	Search	Search
×	r1	0	WEIGHT		3 ~	3 🗸		Lower	38.



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(3)

10 20 30 40 50

5

Configure Optimization Settings

- 1. Click Settings
- Set P2 to 12 Print constraints and responses
- The P2 setting controls the output of the following information to the F06 file: objective, constraints, responses, properties and design variables.
- This is a topometry optimization and will generate a large amount of property and design variable data in the F06 file. To make the F06 file size manageable, the design variable information is omitted by using the P2=12 option. When the results are viewed, note that the objective and constraint information is plotted, but the design variable history is not plotted due to the P2=12 option.
- If this is a combined size and topometry optimization, P2 should be set to 15. If this is a pure size optimization, P2 should be set to 15.

Optimization Settings

-		• • • • • • • • • • • • • • • • • • •
Parameter 🌩	Description 🗢	Configure ≑
Search	Search	Search
APRCOD	Approximation method to be used	2 - Mixed Method
CONV1	Relative criterion to detect convergence	Enter a positive real number
CONV2	Absolute criterion to detect convergence	Enter a positive real number
DELX	Fractional change allowed in each design variable during any optimization cycle	Enter a positive real number
DESMAX	Maximum number of design cycles to be performed	20
DISBEG	Design cycle number for discrete variable processing initiation	Enter a positive integer
GMAX	Maximum constraint violation allowed at the converged optimum	Enter a positive real number
P1	Print items, e.g. objective, design variables, at every n-th design cycle to the .f06 file	☑ 1
P2	Items to be printed to the .f06 file	✓ 12 - Print constraints and respons ✓
TCHECK	Topology Checkerboarding	-1 - Automatic selection (Default) 🗸
TDMIN	Minimum diameter of members in topology optimization	Enter a positive real number
TREGION	Trust Region	🗌 1 - Trust Region On 🗸



Other

Match

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"

BDF Output - Model

assign userfile = 'optimization_results.csv', status = unknown,
form = formatted, unit = 52
\$ id msc, tomex5.dat \$ xmy 3-Mar-2009 mdr4
\$ PCOMP PLY-BY-PLY TOPOMETRY OPT
SOL 200
CEND
SEALL = ALL
SUPER = ALL
TITLE = PCOMP PLY-BY-PLY TOPOMETRY WITH IPOPT
ECHO = NONE
MAXLINES = 999999999
DESOBJ(MIN) = 8000000
DESGLB = 4000000
\$ DSAPRT(FORMATTED, EXPORT, END=SENS) = ALL
SUBCASE 1
ANALYSIS = STATICS
\$ DESSUB Slot
\$ DRSPAN Slot
SUBTITLE=Default
SPC = 1
LOAD = 3
displacement(plot,sorti,real)=all
<pre>spcforces(plot,sort1,real)=all</pre>
stress(plot,sort1,real,vonmises,center)=all
BEGIN BULK
INCLUDE './design_model.bdf'

Download BDF Files





Developed by The Engineering Lab

BDF Output - Design Model





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< >

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.

A albatross > Downloads >	~					×
anize Share with New folder Favorites Desktop Deskt	🔵 🗢 🚺 🕨 albatross	s ► Downloads ►	•	✓ Search Downlo	ads	Q
Favorites Name Date modified Type Desktop Imastran_working_directory.zip Imastran_working_directory.zip Imastran_working_directory.zip OneDrive Imastran_working_directory.zip Imastran_working_directory.zip Imastran_working_directory.zip Ibraries Imastran_working_directory.zip Imastran_working_directory.zip Imastran_working_directory.zip Monegroup Cut Copy Computer Compressed (zipped) Folder Size: 114 bytes	janize 🔻 🛛 😭 Open	n ▼ Share with ▼	New folder	8==	• 🔳	0
Desktop Jastran_working_directory.zip JOP Downloads Open in new window Precent Places Open with Documents Wasic Pictures Videos Homegroup Cut Computer Cut Network If Inastran_working_directory.zip Properties Send to • Computer Cut Network If Inastran_working_directory.zip Properties Select a Destinatio • Compressed (zipped) Folder Size: 114 bytes Select a Destinatio © Show extracted files to started files to starte started files to starte started files to starte started files t	Favorites	Name		Date modified	T I	уре
Recent Places OneDrive Libraries Documents Music Pictures Videos Homegroup Computer Network Image: Compressed (zipped) Folder Size: 114 bytes Select a Destination Files will be extracted files with	Desktop	🔒 nastran_working	_directory.zip	0pen	5.0.04 (omoress
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Music Pictures Videos Homegroup Computer Network Image: Seed to Cut Copy Create shortcut Delete Rename Properties Compressed (zipped) Folder Size: 114 bytes Select a Destination and E Files will be extracted to this folde CUt Copy Create shortcut Delete Rename Properties Select a Destination and E Files will be extracted to this folde CUSers/userA/DownloadAynastre Show extracted files when com	Documents			Open with		
Videos Videos Homegroup Computer Network nastran_working_directory.zip Date modified: 2/25/2 Compressed (zipped) Folder Size: 114 bytes Size: 114 bytes Select a Destination and Ext Files will be extracted to this folder: CAUSers/user/Downloads/mastran Show extracted files when compl	Music			Share with Restore previous ver	sions	
Homegroup Computer Network nastran_working_directory.zip Date modified: 2/25/2 Compressed (zipped) Folder Size: 114 bytes Size: 114 bytes Select a Destination and Extra Files will be extracted to this folder: (CUtsers/useA/Downloads/nastran_w) Show extracted files when complet	Videos			Send to		+
Homegroup Computer Network nastran_working_directory.zip Date modified: 2/25/2 Compressed (zipped) Folder Size: 114 bytes Select a Destination and Extra Files will be extracted to this folder:	10674			Cut		
Computer Network nastran_working_directory.zip Date modified: 2/25/2 Compressed (zipped) Folder Size: 114 bytes Select a Destination and Extract Files will be extracted to this folder: C:\Users\user\Downloads\nastran_work Show extracted files when complete	Homegroup			Сору		
Network	Computer			Create shortcut		
Nastran_working_directory.zip Date modified: 2/25/2 Compressed (zipped) Folder Size: 114 bytes Select a Destination and Extract Fi Files will be extracted to this folder: CAUSers/user/Downloads/nastran_working If Show extracted files when complete				Delete		
nastran_working_directory.zip Date modified: 2/25/2 Properties Compressed (zipped) Folder Size: 114 bytes Select a Destination and Extract File: Files will be extracted to this folder: C\Users\user\Downloads\nastran_working_d Show extracted files when complete	Network	•	III	Rename		•
Compressed (zipped) Folder Size: 114 bytes Size: 114 bytes Select a Destination and Extract Files Files will be extracted to this folder: C:\Users\user\Downloads\nastran_working_dir Show extracted files when complete	nastran_worki	ing_directory.zip Date	modified: 2/25/2	Properties		
Select a Destination and Extract Files Files will be extracted to this folder: C:\Users\user\Downloads\nastran_working_dir I Show extracted files when complete	Compressed (zi	ipped) Folder	Size: 114 bytes	G) 🚺 Ext	ract Com
Select a Destination and Extract Files Files will be extracted to this folder: C:\Users\user\Downloads\nastran_working_dir Show extracted files when complete						
Files will be extracted to this folder: C:\Users\user\Downloads\nastran_working_dire Image: Show extracted files when complete					Select	a Dest
C:\Users\user\Downloads\nastran_working_directory Show extracted files when complete					Files wi	ll be extra
Show extracted files when complete					C:\Use	ers\user\[
					Show	v extracte



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

🗸 🖓 🖉 Downl 🕨 nastran_working_directory 🕨 🗸 🗸	✓ Search nastran_worki	ing_dir 🔎	
Organize Include in library Share with New folder	:== ▼		n File
Favorites	Date modified	Туре	
💻 Desktop	2/24/2018 1:57 PM	File folder D	o you
📕 Downloads 🛛 🖉 design_model.bdf	2/24/2018 1:57 PM	BDF File	
🕮 Recent Places 📄 model.bdf	2/24/2018 1:57 PM	BDF File	7
ConeDrive 🛛 🔁 Start MSC Nastran	2/24/2018 1:57 PM	Shortcut	
Libraries Documents] Alwaj
⊷ Homegroup		(





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



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

network 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.

- Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
- The final value of objective, normalized constraints (not shown here) and design variables can be reviewed.
- Note that in a Topometry optimization, hundreds or thousands of design variables can be created. In this situation, the Design Variables are not plotted and displayed. Instead, the Objective and Normalized Constraints are displayed. It is recommended that a traditional postprocessor be used to review the design variable results.

1 Final Message in .f06

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

Objective



8.



Design Cycle





- 1. Start a new Patran session
- 2. Right click to open a menu
- 3. Go to Import Model and click on MSC.Nastran Input
- Select model.bdf (This file was used for the optimization)
- 5. Click Apply





Review Optimization Results in Patran

- 1. Click Smooth Shading
- Go to Tools > Design Study and click on Post-Process
- 3. Click Select Results File
- 4. Type "*.ply" and press the enter key to show all the files in the folder
- 5. Select model.ply0001 (This file was created during the optimization)
- 6. Click OK
- 7. Click Apply
- 8. Repeat steps 3-7 for the following files:
 - 1. model.ply0002





Review Optimization Results in Patran

- 1. Click the clear icon
- 2. Click Results
- 3. Set the following:
 - Action: Create
 - Object: Fringe
- 4. Select: DESIGN CYCLE: 8, model.ply0001 (The row should be highlighted blue)
- Select Topology Optimization, Element D...(The row should be highlighted blue)
- 6. Click Apply
- 7. Repeat steps 4-6 for the following:
 - DESIGN CYCLE: 8, model.ply0002







Reset

Animate

Apply

6

Ensure the BDF files prior to optimization have one of these entries:

- H5 Output
 - MDLPRM HDF5
 - HDF5OUT INPUT YES

MDLPRM HDF5 is supported in MSC Nastran 2016.1 and newer. HDF5OUT is supported in MSC Nastran 2022.2 and newer.

The following applies to MSC Nastran 2023.4 and older. For MSC Nastran 2024.1, this is not needed.

Change DESPCH1 to 1

- DESPCH
 - Before:

PARAM DESPCH1 -1

- After:
 - PARAM DESPCH11

DESPCH1 -1 outputs entries to the PCH file in the small field format. Since the PSHELL IDs are longer than 8 characters, the IDs appear as asterisk characters, e.g. *******. DESPCH1 1 outputs the entries in the large field format, so the IDs are fully visible.

24	CQUAD4	1	1 1	2	23	22	. 24	CQUAD4	1	10000001 1	2	23	22	
25	CQUAD4	2	1 2	3	24	23	25	CQUAD4	2	10000002 2	3	24	23	
26	CQUAD4	3	1 3	4	25	24	= 26	CQUAD4	3	1000003 3	4	25	24	
27	CQUAD4	4	14	5	26	25	27	CQUAD4	4	10000004 4	5	26	25	
8	CQUAD4	5	15	6	27	26	28	CQUAD4	5	10000005 5	6	27	26	
9	CQUAD4	6	16	7	28	27	29	CQUAD4	6	10000006 6	7	28	27	
0	CQUAD4	7	17	8	29	28	30	CQUAD4	7	10000007 7	8	29	28	
1	CQUAD4	8	18	9	30	29	31	CQUAD4	8	10000008 8	9	30	29	
2	CQUAD4	9	19	10	31	30	32	CQUAD4	9	10000009 9	10	31	30	
3	CQUAD4	10	1 10) 11	32	31	33	CQUAD4	10	10000010 10	11	32	31	
4	CQUAD4	11	1 1:	l 12	33	32	34	CQUAD4	11	10000011 11	12	33	32	
5	CQUAD4	12	1 1:	2 13	34	33	35	CQUAD4	12	10000012 12	13	34	33	
6	CQUAD4	13	1 1:	3 14	35	34	36	CQUAD4	13	10000013 13	14	35	34	
7	CQUAD4	14	1 1	1 15	36	35	37	CQUAD4	14	10000014 14	15	36	35	
8	CQUAD4	15	1 1	5 16	37	36	38	CQUAD4	15	10000015 15	16	37	36	
9	CQUAD4	16	1 1	5 17	38	37	39	CQUAD4	16	10000016 16	17	38	37	
0	CQUAD4	17	1 1'	7 18	39	38	40	CQUAD4	17	10000017 17	18	39	38	

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16	Ş	UPDATED ANA	LYSIS MOI	DEL DATA	ENTRIES			<u> </u>	
17	Ş								
18	PC	OMP 100000	10105	0.0	650000.	TSAI	0.0	0.0	SYM
19		7	0 1.5	80.	YES	70	.774108	-65.	YES
20		7	0 1.5	80.	YES	70	.774108	-65.	YES
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25	Ş	MAT2*	11000	0001 1.	92043294	E+06 2.	00203393	E+06 -4.	72326628E+05*
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384	\$ Ultir	nate longitudinal	compres	sive strengt	ch: 217	56E3	PSI	
385	\$ Ultir	nate transverse te	nsile s	strength:	5.	802E3	PSI	
386	\$ Ultir	nate transverse co	mpressi	ve strength:	: 35.	68E3	PSI	
387	\$ Ultir	mate in-plane shea	r stren	igth:	9.	863E3	PSI	
388	Ş							
389	\$ Sourd	ce: Tsai, S.W. and	Hahn,	H.T., Introd	duction	to Co	mposite	Mate
390	\$ FL, 1	Table 1.7, p. 19;	Table 7	.1, p.292; 1	Table 8.	3, p.	342.	
391	\$ 1	2 3	4	5	6	7	8	11
392	MAT8	70 26.25e6	1.49e6	.28 1.0)4e6			.05
393				217560. 217	7560. 58	302.	35683.	986
394	PCOMP	100000010105	0.0	650000.	TSAI	0.0	0.0	
395		70 1.5	80.	YES	70.	77410	8-65.	
396		70 1.5	80.	YES	70.	77410	8-65.	
397	PCOMP	100000020105	0.0	650000.	TSAI	0.0	0.0	
398		70 1.39312	80.	YES	70.	05296	4-65.	
399		70 1.39312	80.	YES	70.	05296	4-65.	
400	PCOMP	100000030105	0.0	650000.	TSAI	0.0	0.0	
401		70 .946061	80.	YES	70.	01197	4-65.	
402		70 .946061	80.	YES	70.	01197	4-65.	
403	PCOMP	100000040105	0.0	650000.	TSAI	0.0	0.0	
404		70 .713549	80.	YES	70.	00113	5-65.	
405		70 .713549	80.	YES	70.	00113	5-65.	
406	PCOMP	100000050105	0.0	650000.	TSAI	0.0	0.0	
407		70 .534361	80.	YES	70.	00113	5-65.	
408		70 .534361	80.	YES	70.	00113	5-65.	
409	PCOMP	100000060105	0.0	650000.	TSAI	0.0	0.0	
410		70 .399395	80.	YES	70.	00114	2-65.	
411		70 .399395	80.	YES	70.	00114	2-65.	
412	PCOMP	100000070105	0.0	650000.	TSAI	0.0	0.0	
413		70 .317016	80.	YES	70 .	.00312	-65.	
414		70 .317016	80.	YES	70 .	00312	-65.	

PCH

Downloaded BDF/DAT File



E

1. This Python script is used to automate the update the process.

```
import h5py
import hdf5plugin # This library is necessary when HDF50UT is used (Approximately MSC Nastran 2021 and newer)
import re
def get dataset cquad4(path of h5 file):
   file = h5py.File(path_of_h5_file, 'r')
dataset1 = file['/NASTRAN/INPUT/ELEMENT/CQUAD4']
   dataset original = dataset1[...]
   list of objects = []
   for element in dataset_original:
       # Store the following fields EID, PID, G1, G2, G3, G4
       list of objects.append(
           - {
               'eid': element[0],
               'pid': element[1],
               'ql': element[2][0],
               'g2': element[2][1],
               'g3': element[2][2],
               'g4': element[2][3]
           }
       )
   return list of objects
def read_cquad4_entries_from_h5_and_write_to_bdf(path_a, path_of_new_bdf_file):
    objects_a = get_dataset_cquad4(path_a)
   list_of_strings = []
   for element i in objects a:
      # Write the fields to an array/list
       # Ensure all array elements are strings so ','.join() works properly
       array of fields = [
           str(element_i['eid']),
           str(element i['pid']),
           str(element i['ql']),
           str(element i['g2']),
           str(element i['g3']),
           str(element_i['g4'])
       1
       # Create the entry with comma delimiters, which is the free field format
       list_of_strings.append(','.join(array_of_fields))
   # Write the strings to a text file
   file = open(path_of_new_bdf_file, 'w')
   for item in list of strings:
       file.write(item + '\n')
   file.close()
def filter entries from pch (path of pch file, name of entry, path of new bdf file):
   # This function reads a PCH file and keeps specific entries
   # Before (PCH File):
   # PCOMP 10000001-.0105 0.0 650000. TSAI 0.0 0.0
                                                                       SYM
                  70 1.5 80.
                                        YES 70 .774108-65.
                                                                       YES
   #
                  70 1.5 80.
                                        YES
                                                 70 .774108-65.
                                                                       YES
   ÷.
   # $ Spawned PSHELL, MAT2 entries from PCOMP 10000001
   # $ PSHELL*
                                    110000001 9.09643308E+00
   # S *
                  1.0000000E+00
                                             0 1.0000000E+00 0.0000000E+00*
   # After (new entries.bdf):
   # PCOMP 10000001-.0105 0.0 650000. TSAI 0.0 0.0
                  70 1.5 80.
                                        YES
                                                70 .774108-65.
                                                                       YES
   ÷.
                  70 1.5 80.
                                        YES
                                               70 .774108-65.
                                                                       YES
   file = open(path of pch file, 'r')
   file_b = open(path_of_new_bdf_file, 'w')
   keep line = False
   keep continuation line = False
   # Example: Suppose you only want to read PCOMP entries
   # 1 PCOMP 10000001-.0105 0.0 650000. TSAI 0.0 0.0
                                                                          SYM
```

# 2		70	1.5	80.	YES	70	.774108-	65.	YES		
# 3		70	1.5	80.	YES	70	.774108-	65.	YES		
# 4	MAT1	101									
# 5	PSHELL*		10000001		10000001	9.09643	308E+00	21	0000001*		
# 6	*	1.0000	0000E+00		0	1.00000	000E+00	0.00000	000E+00*		
# 7	*	-1.0500	0000E-02	9.085	3308E+00	41	10000001				
# 8	\$MAT2*		11000000	1 1.920	043294E+06	2.0020)3393E+06	-4.7232	6628E+05*		
# 9	\$*	2.277	76275E+0	7 3.502	255102E+04	2.6229	96904E+06	5.8526	0000E-02*		
# 10	s*	0.000	00000E+0	0 0.000	00000E+00	0.0000	0000E+00	0.0000	0000E+00*		
# 11	s*	0.000	00000E+0	0 0.000	00000E+00	0.0000	0000E+00	0.0000	0000E+00*		
# 12	s*			0							
# 13	PCOMP	10000002	- 0105	- 0.0	650000	TSAT	0.0	0.0	SYM		
# 14	100111	70	1 5	80	YES	70	774108-	65	YES		
# 15		70	1.5	80	VES	70	774108-	65	VES		
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	keep_	nteb (mlo)	.ue	line	in Nana						
e.	ur re.m	atch(r ((^ (S+))	, iine)	is None:	10 11	10.000				
	# 101	s detects	i iines 4	, , , ,	1, 0, 9,	10, 11,	12 Which	are oun	ler entries i	iot to keep	
	keep_	line = Fa	use								
	keep_	continuat	ion_line	= False	5						
i	f keep_1	ine is Tr	ue:								
	if re	.match(r'	^(* \s+)', line	e):						
	#	This det	ects lin	es 2, 3,	14, 15 w	hich are	e continu	ation li	nes of the	entry	
	k	eep_conti	nuation_	line = !	Irue						
ii	f re.mat	ch(r'\\$',	line) i	s None:							
	# Thi	s detects	all lin	es, exce	ept lines	8, 9, 10), 11, 12	which a	re commente	d with \$	
	if ke	ep line <mark>i</mark>	s True o	r keep o	continuati	on line	is True:				
	#	Write th	e line t	o a new	file	-					
	f	ile b.wri	te(line)								
		-									
file.c	close()										
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if name	'	, main '.									
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<pre>ifname_</pre>	<pre></pre>		t output i path b, g MDLFNM the H5 Download Download ments Af ######## 1,2,16, ,2,3,17, ,2,3,17, ,3,4,18, ,4,5,19, ,5,6,20, (6,7,21, 7,8,28)	s update then rr ;HDF5,1 file. Tr s/nastra ter Tope ######## s d_write 15 16 17 18 19 20 21	ed PCOMP a in this sc is used, we INPUT d an_working in_working metry Opt ######### to_bdf (pa	nd CQUAI ript which t: _directo _directo imizatio ######## th_a, 'r	04 elemen riggers t are the ory/model ory/model on n www.sp_elemew_2D_el	ts after he outpu bulk dat .h5' .pch'	an MSC Nas t of the a entries: (######### mp')	tran topometry opt	imization. HELLS,
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<pre>ifname_</pre>	<pre>ments This pyt Modify p This wor iNPUT da a = '/ho b = '/ho out New ######### put upda cquad4_e put AD4*,1,1 AD4*,2,1 AD4*,5,1 AD4*,5,1 AD4*,5,1 .] put New</pre>	<pre></pre>	t output l path b, g MDLFMM the H5 Download ments Af ######## (,2,3,17, ,3,4,18, ,4,5,19, ,5,6,20, ,5,6,20, ,7,7,21, ,7,8,22, riss Aft	s update then rr ;HDF5,1 ;HDF5,1 ; s/nastr ; s/nastr ; s/nastr ; d_write 15 16 17 18 19 20 21 21	ed PCOMP a in this sc is used, working metry Opt to_bdf (pa	nd CQUAI ript which ti directo directo timizatio ######## th_a, 'r	D4 elemen riggers t are the ory/model on ######## hew_2D_el	ts after he outpu bulk dat .h5' .pch' ######## ements.t	<pre>an MSC Nas: it of the a entries: (######### mp')</pre>	tran topometry opt	imization.
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<pre>ifname_</pre>	<pre>ments This pyt Modify p This wor in put New ####################################</pre>	<pre></pre>	t output l path_b, g MDLFRM the H5 Download ments Af ######## (,2,3,17, ;3,4,18, ,5,6,20, ,6,7,21, ,7,8,22, riss Att ######## h (path_b 05 0	s updata then rr ;HDFS,1 ;HDFS,1 ter Topa ######## d_write_ 15 16 17 18 19 20 21 er Topod ####### ; 'PCOMI .0 655	<pre>dd PCOMP at un this sc is used, an_working an_working metry Opti to_bdf (pa netry Opti ;;******** ?', 'new_p 0000. T</pre>	nd CQUAI ript which ty atasets directc directc directc th_a, 'r th_a, 'r mization ######## comp_ent SAI 0.	04 elemen riggers t are the bry/model bry/model on ########## new_2D_el a ################ cries.tmp 0 0.	<pre>ts after he outpu bulk dat .h5' .pch' ######### ements.t ######### ') 0</pre>	an MSC Nas: at of the a entries: (######### mp') ########## SYM	tran topometry opt	imization. HELLS,
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<pre>ifname_</pre>	<pre>ments This pyt Modify p This wori INPUT da a = '/ho b = '/ho put New ####################################</pre>		t output path b, g MDLFMM + the H5 Download Download Download ments Aff ######### 44 entrie room, 5_ an ,1,2,16, ,2,3,17, ,3,4,18, ,4,5,19, ,5,6,20, ,5,6,20, ries Aft ######### h (path b 80. 05 00	s update then rr ;HDF5,1 ;HDF5,1 ;s/nastra ;s/nastra ;s/nastra ; d_write d_write 15 16 17 18 19 20 21 er Topor ####### ; 'PCOMI .0 650 .0 650	ed PCOMP a in this sc is used, he INPUT d an_working mmetry Opti ####################################	nd CQUAI ript which ty atasets directc imizatio ######## th_a, 'r mization ####### SAI 0. 70.777 70.777	04 elemen riggers t are the ory/model on tew_2D_el new_2D_el text ries.tmp 108-65. 1108-65. 0 0.0.	<pre>ts after he outpu bulk dat .h5' .pch' ######### ements.t ********** ') 0 0</pre>	an MSC Nas t of the a entries: (""""""""""""""""""""""""""""""""""""	tran topometry opt	imization. HELLS,
<pre>ifname</pre>	<pre>ments This pyt Modify p This wor INFUT da a = '/ho b = '/ho put New ######### cquad4_e put AD4*,2,1 AD4*,2,1 AD4*,4,1,1 AD4*,5,1 AD4*,5,1 AD4*,7,1 .] put New ################ r entrie puts MP 100 MP 100</pre>	<pre></pre>	t output path_b, g MDLFRM the H5 Download ments Af ######## (4 entrie com_h5_an ,1,2,16, ,2,3,17, ,3,4,18, ,4,5,19, ,5,6,20, ,6,7,21, ,7,8,22, riss Aft ######## h (path_b 05 0 80. 80. 80. 80. 80. 80. 80. 80	s updat, then ri ,HDF5,1 file. Ti s/nastri ter Topor ######## 15 16 17 18 19 20 21 er Topor ####### , 'PCOMI .0 650	<pre>dd PCOMP a un this sc is used, e INPUT d metry Opti to_bdf (pa hetry Opti ********** ?', 'new_p >0000. T YES >0000. T YES >0000. T</pre>	nd CQUAI ript which tr atasets directc directc imization ######### th_a, 'r mization ######## comp_ent SAI 0. 70.774 SAI 0. 70.772 SAI 0. 70.772	04 elemen riggers t are the bry/model on ######## new_2D_el hew_2D_el 0 0. 1108-65. 1108-65. 0 0.	<pre>ts after he outpu bulk dat .h5' .pch' ######### ements.t ********* ') 0 0</pre>	an MSC Nas: t of the a entries: (########## mp') ########### SYM YES SYM YES SYM	tran topometry opt	imization. HELLS,
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The Python script generates a new TMP file.

1. Copy and paste the CQUAD4 elements to the original BDF file.

📄 new_2D_	elements.tmp 🗵	4	tomex500.	dat 🗵						
1	CQUAD4,1,10000001,1,2,23,22		24	CQUAD4	1	1	1	2	23	22
2	CQUAD4,2,10000002,2,3,24,23	E	25	CQUAD4	2	1	2	3	24	23
3	CQUAD4,3,10000003,3,4,25,24		26	CQUAD4	3	1	3	4	25	24
4	CQUAD4,4,10000004,4,5,26,25		27	CQUAD4	4	1	4	5	26	25
5	CQUAD4,5,10000005,5,6,27,26		28	CQUAD4	5	1	5	6	27	26
6	CQUAD4,6,10000006,6,7,28,27		29	CQUAD4	6	1	6	7	28	27
7	CQUAD4,7,10000007,7,8,29,28		30	CQUAD4	7	1	7	8	29	28
8	CQUAD4,8,10000008,8,9,30,29		31	CQUAD4	8	1	8	9	30	29
9	CQUAD4,9,10000009,9,10,31,30		32	CQUAD4	9	1	9	10	31	30
10	CQUAD4,10,10000010,10,11,32,31		33	CQUAD4	10	1	10	11	32	31
11	CQUAD4,11,10000011,11,12,33,32		34	CQUAD4	11	1	11	12	33	32
12	CQUAD4,12,10000012,12,13,34,33		35	CQUAD4	12	1	12	13	34	33
13	CQUAD4,13,10000013,13,14,35,34		36	CQUAD4	13	1	13	14	35	34
14	CQUAD4,14,10000014,14,15,36,35		37	CQUAD4	14	1	14	15	36	35
15	CQUAD4,15,10000015,15,16,37,36		38	CQUAD4	15	1	15	16	37	36
16	CQUAD4,16,10000016,16,17,38,37		39	CQUAD4	16	1	16	17	38	37
17	CQUAD4,17,10000017,17,18,39,38		40	CQUAD4	17	1	17	18	39	38
18	CQUAD4,18,10000018,18,19,40,39		41	CQUAD4	18	1	18	19	40	39
19	CQUAD4,19,10000019,19,20,41,40		42	CQUAD4	19	1	19	20	41	40
20	CQUAD4,20,10000020,20,21,42,41		43	CQUAD4	20	1	20	21	42	41
21	CQUAD4,21,10000021,22,23,44,43		44	CQUAD4	21	1	22	23	44	43
22	CQUAD4,22,10000022,23,24,45,44		45	CQUAD4	22	1	23	24	45	44
23	CQUAD4,23,10000023,24,25,46,45		46	CQUAD4	23	1	24	25	46	45
24	CQUAD4,24,10000024,25,26,47,46		47	CQUAD4	24	1	25	26	47	46
25	CQUAD4,25,10000025,26,27,48,47		48	CQUAD4	25	1	26	27	48	47
26	CQUAD4,26,10000026,27,28,49,48		49	CQUAD4	26	1	27	28	49	48
27	CQUAD4,27,10000027,28,29,50,49		50	CQUAD4	27	1	28	29	50	49
28	CQUAD4,28,10000028,29,30,51,50		51	CQUAD4	28	1	29	30	51	50
29	CQUAD4,29,10000029,30,31,52,51		52	CQUAD4	29	1	30	31	52	51
30	CQUAD4,30,10000030,31,32,53,52		53	CQUAD4	30	1	31	32	53	52
31	CQUAD4,31,10000031,32,33,54,53		54	CQUAD4	31	1	32	33	54	53
32	CQUAD4,32,10000032,33,34,55,54		55	CQUAD4	32	1	33	34	55	54
33	CQUAD4,33,10000033,34,35,56,55		56	CQUAD4	33	1	34	35	56	55
34	CQUAD4,34,10000034,35,36,57,56		57	CQUAD4	34	1	35	36	57	56
)								
							J			



new_2D_elements.tmp



Original BDF File

The Python script generates a new TMP file.

1. Copy and paste the PCOMP entries to the original BDF file.

PCOME	10000010105 0.0	650000.	TSAI 0.0 0.0	SYM 4	1364	SPC1 1 123456 1 THRU 21
	70 1.5 80.	YES	70 .774108-65.	YES	1365	LOAD 3 1. 1. 1
	70 1.5 80.	YES	70 .774108-65.	YES	1366	\$ Nodal Forces of Load Set : force
PCOME	10000020105 0.0	650000.	TSAI 0.0 0.0	SYM	1367	FORCE 1 683 0 300. 11. 0.
	70 1.39312 80.	YES	70 .052964-65.	YES	1368	\$ Referenced Coordinate Frames
	70 1.39312 80.	YES	70 .052964-65.	YES	1369	mat1 1 2.07+5 .3 7.93
PCOM	100000030105 0.0	650000.	TSAI 0.0 0.0	SYM	1370	PCOMP 10105 0.0 0.65E6 TSAI SYM
	70 .946061 80.	YES	70 .011974-65.	YES	1371	70 1.000 80. YES 70 1.000 -65. YES
	70 .946061 80.	YES	70 .011974-65.	YES	1372	70 1.000 80. YES 70 1.000 -65. YES
COM	100000040105 0.0	650000.	TSAI 0.0 0.0	SYM	1373	\$ 1 2 3 4 ↑ 5 6 7 8 9
	70 .713549 80.	YES	70 .001135-65.	YES	1374	\$ Composite Type: T300/5208 (Graphite/Expoxy)
	70 .713549 80.	YES	70 .001135-65.	YES	1375	Ş
COM	100000050105 0.0	650000.	TSAI 0.0 0.0	SYM	1376	\$ E1: 26.25E6 PSI
	70 .534361 80.	YES	70 .001135-65.	YES	1377	\$ E2: 1.49E6 PSI
	70 .534361 80.	YES	70 .001135-65.	YES	1378	\$ v12: .28
PCOM	100000060105 0.0	650000.	TSAI 0.0 0.0	SYM	1379	\$ G12: 1.04E6 PSI
	70 .399395 80.	YES	70 .001142-65.	YES	1380	Ş
	70 .399395 80.	YES	70 .001142-65.	YES	1381	\$ Density: 5.8526E-2 lbm/in^3
PCOM	100000070105 0.0	650000.	TSAI 0.0 0.0	SYM	1382	Ş
	70 .317016 80.	YES	70 .00312 -65.	YES	1383	\$ Ultimate longitudinal tensile strength: 217.56E3 PSI
	70 .317016 80.	YES	70 .00312 -65.	YES	1384	\$ Ultimate longitudinal compressive strength: 217.56E3 PSI
PCOM	100000080105 0.0	650000.	TSAI 0.0 0.0	SYM	1385	<pre>\$ Ultimate transverse tensile strength: 5.802E3 PSI</pre>
	70 .25365 80.	YES	70 .015178-65.	YES	1386	S Ultimate transverse compressive strength: 35.68E3 PSI
	70 .25365 80.	YES	70 .015178-65.	YES	1387	\$ Ultimate in-plane shear strength: 9.863E3 PSI
PCOM	100000090105 0.0	650000.	TSAI 0.0 0.0	SYM	1388	Ş
	70 .205456 80.	YES	70 .020367-65.	YES	1389	\$ Source: Tsai, S.W. and Hahn, H.T., Introduction to Composite Materials
	70 .205456 80.	YES	70 .020367-65.	YES	1390	\$ FL, Table 1.7, p. 19; Table 7.1, p.292; Table 8.3, p. 342.
PCOME	100000100105 0.0	650000.	TSAI 0.0 0.0	SYM	1391	\$ 1 2 3 4 5 6 7 8 9
	70 .161272 80.	YES	70 .021622-65.	YES	1392	MAT8 70 26.25e6 1.49e6 .28 1.04e6 .058526
	70 .161272 80.	YES	70 .021622-65.	YES	1393	217560. 217560. 5802. 35683. 9863.
PCOM	100000110105 0.0	650000.	TSAI 0.0 0.0	SYM	1394	ENDDATA 5c8b7a30
	70 116866 80	VFC	70 055676-65	VES	1395	

(1)

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

new_pcomp_entries.tmp





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

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Ply drop offs are employed for the -65 degree plies. In the interest of manufacturability, ply drop offs are not employed for the 80 degree plies.



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HEXAGON Technology Partner

Before Optimization

• Panel of initial layup

After Optimization

- Panel of updated layups
- The weight is reduced





End of Tutorial

