

Vibration of a Cantilevered Beam (Turner's Problem), Nastran Optimization

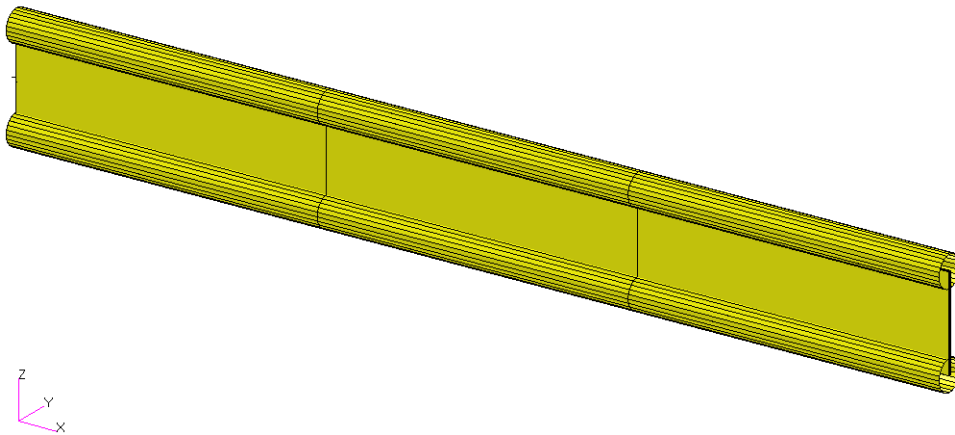
PRESENTED BY CHRISTIAN APARICIO

Goal: Use Nastran SOL 200 Optimization

Minimize the weight of this structure while constraining the 1st natural frequency

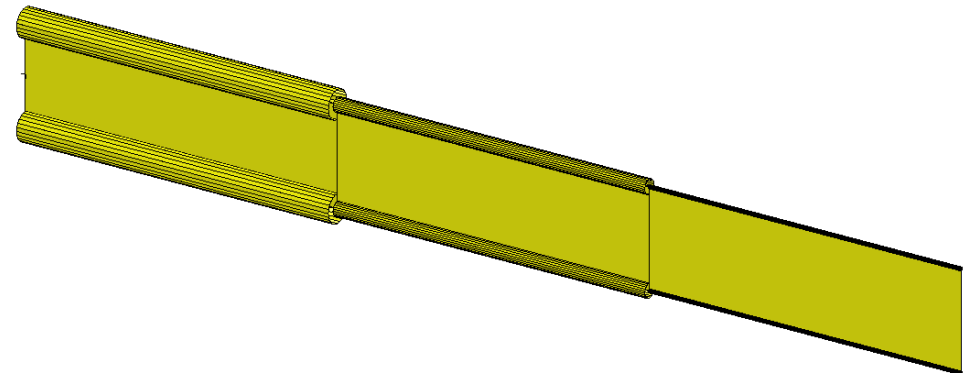
Before Optimization

- Weight: 19.2 lbs.
- 1st Natural Frequency: 26 Hz



After Optimization

- Weight: 6.97 lbs.
- 1st Natural Frequency: 20 Hz



*MSC Nastran Design Sensitivity and Optimization User's Guide
Chapter 8 – Example Problems - Vibration of a Cantilevered Beam (Turner's Problem)*

Agenda

Details of the structural model

Optimization Problem Statement

Steps to use Nastran SOL 200 (Optimization)

- Convert a .bdf file to SOL 200
- Create:
 - Design Variables
 - Design Objective
 - Design Constraints
- Perform optimization with Nastran SOL 200

View optimization results

- Online Plotter
- Structural Results

Update the original structural model with optimized parameters

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

Details of the structural model

Vibration of a Cantilevered Beam (Turner's Problem)

This problem was originally published by M.J. Turner (see Reference 13.). The problem is to design a minimum weight structure while constraining the fundamental natural frequency to be at or above 20 Hz. The beam is symmetric about $Z = 0$ and made up of a shear web having top and bottom caps that are modeled with rod elements. Turner's original design model consisted of piecewise linear bar cross-sectional areas and web thicknesses; however, we will just approximate this as a step function model with uniform cross-sectional rod elements and uniform thickness shear elements within each of three bays.

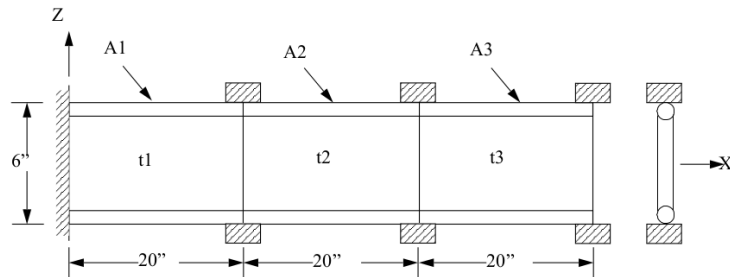
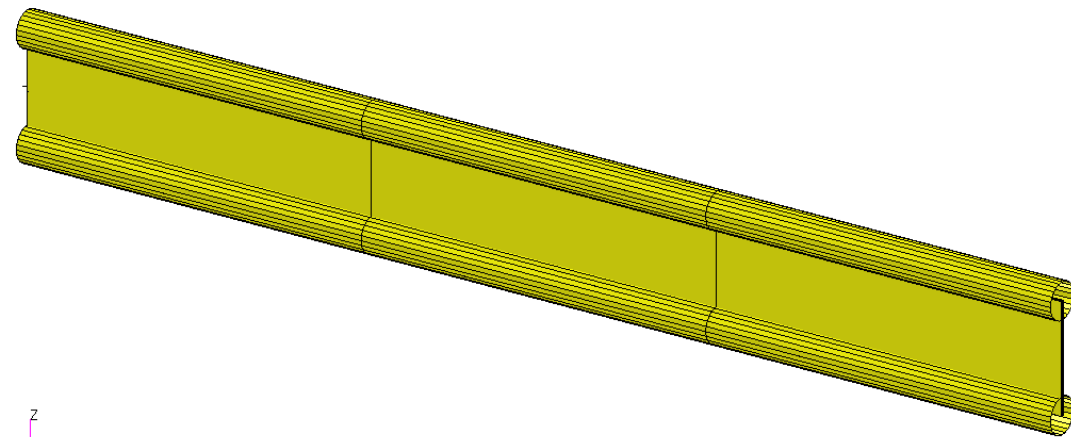
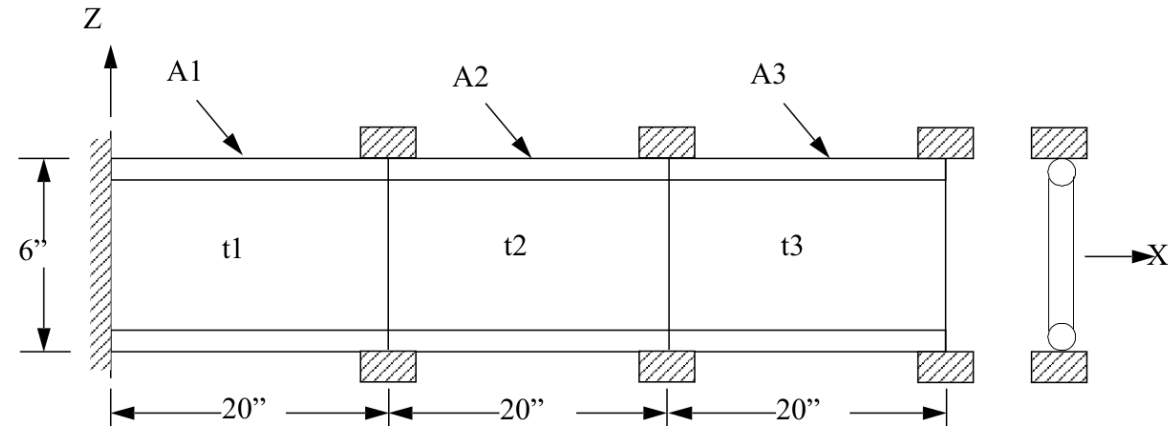


Figure 8-17 Cantilever Beam Vibration Model

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Beam (Turner's Problem)



Optimization Problem Statement

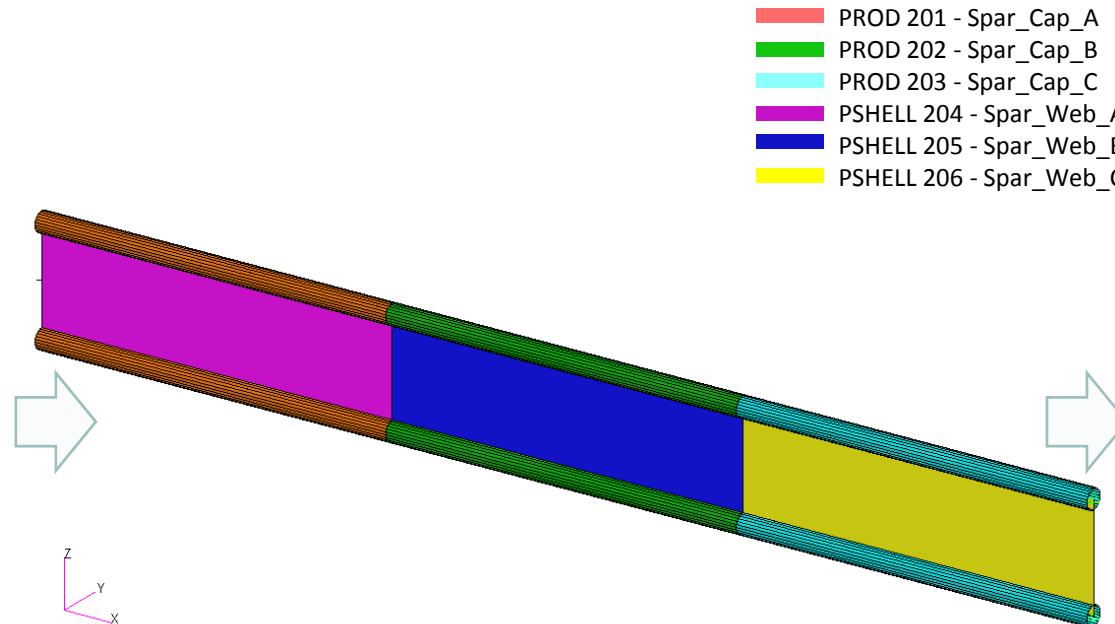
Design Variables

x1: A of PROD 201
x2: A of PROD 202
x3: A of PROD 203

$$.01 < x1, x2, x3 < 100.$$

x4: T of PSHELL 204
x5: T of PSHELL 205
x6: T of PSHELL 206

$$.0002 < x4, x5, x6 < 2.$$



Responses (Outputs)

- Frequencies
- Mode shapes
-

Optimization Problem Statement

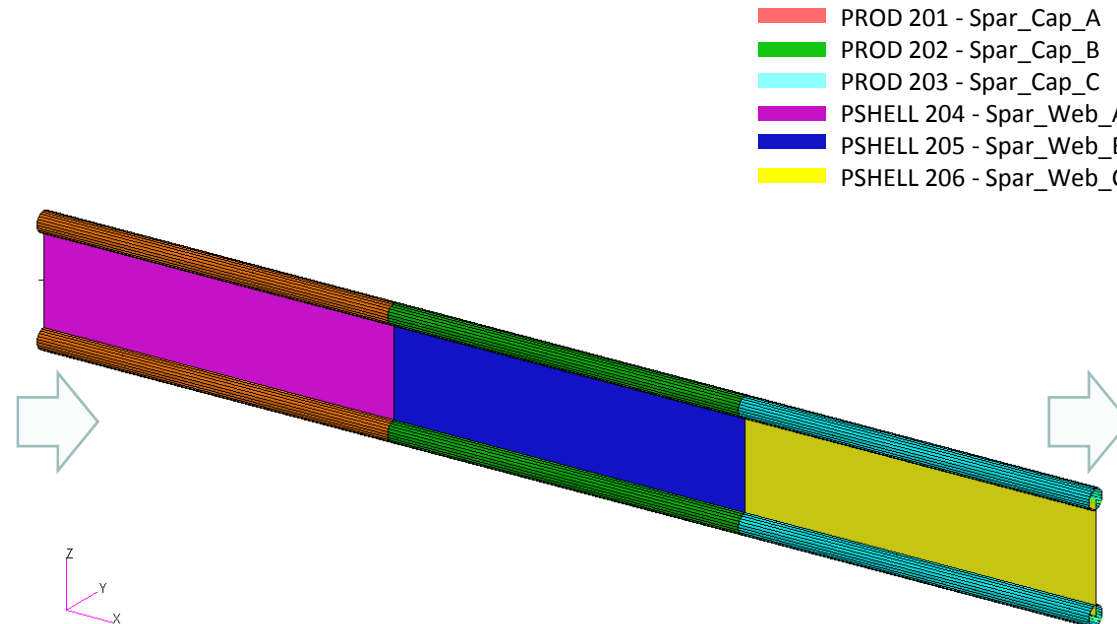
Design Variables

x1: A of PROD 201
x2: A of PROD 202
x3: A of PROD 203

$$.01 < x1, x2, x3 < 100.$$

x4: T of PSHELL 204
x5: T of PSHELL 205
x6: T of PSHELL 206

$$.0002 < x4, x5, x6 < 2.$$



Design Objective, Equation

R0: Minimize $a1 - 90$.

where,

$a1$: weight of entire structure

Design Constraints

r1: 1st Natural frequency

$$20 \text{ Hz} < r1$$

Optimization Problem Statement

1. Design Variables

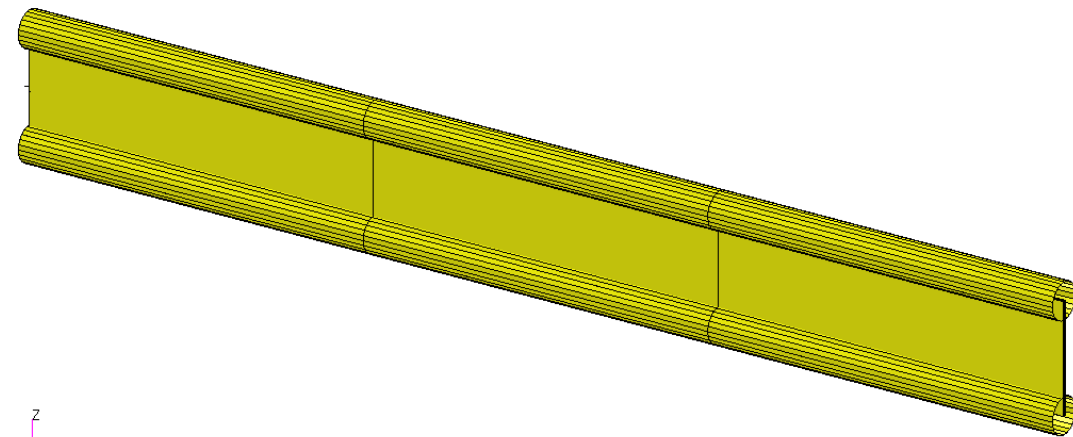
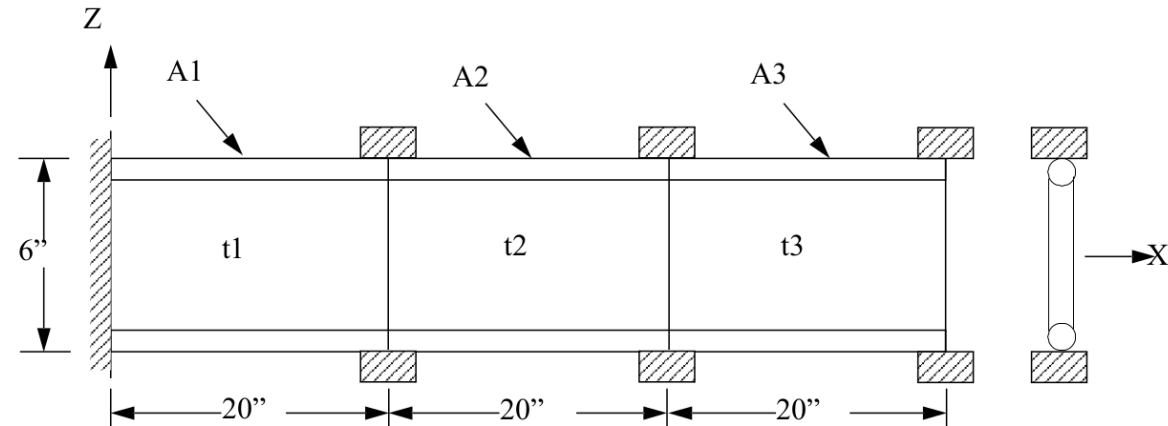
- x_1 : A_1 | $.01 < x_1 < 100$.
- x_2 : A_3 | $.01 < x_2 < 100$.
- x_3 : A_3 | $.01 < x_3 < 100$.
- x_4 : T_1 | $.0002 < x_4 < 2$.
- x_5 : T_3 | $.0002 < x_5 < 2$.
- x_6 : T_3 | $.0002 < x_6 < 2$.

2. Design Objective, Equation

- Minimize R_0
 - R_0 : a1 - 90. lbs.
 - a1: Weight

3. Design Constraints

- r_1 : 1st Natural Frequency
 - $20. \text{ Hz} < r_1$



Steps to use Nastran SOL 200 (Optimization)

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. Review optimization results
 - Online Plotter
 - Optimized structural results
4. Update the original model with optimized parameters

SOL 200 Web App Capabilities

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

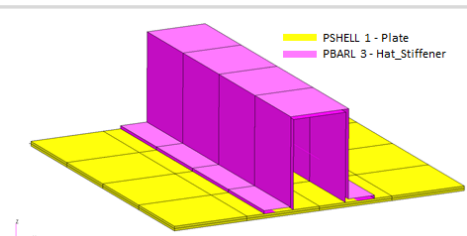
Compatibility

- 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.

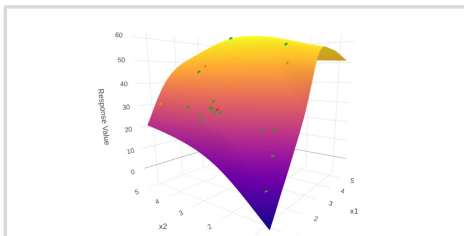
Benefits

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

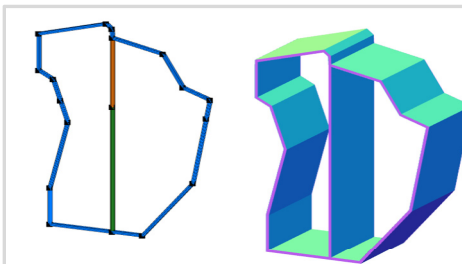
Web Apps



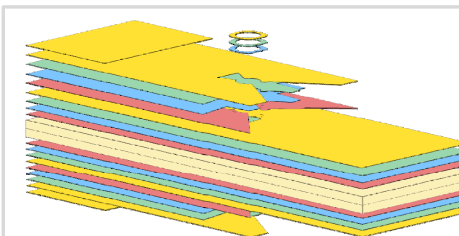
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200.
Support for size, topology, topometry, topography, multi-model optimization.



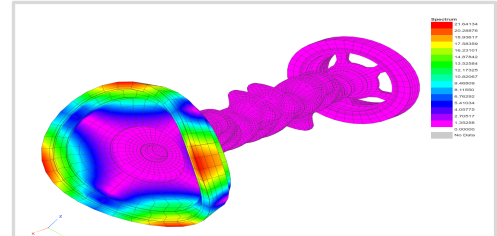
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



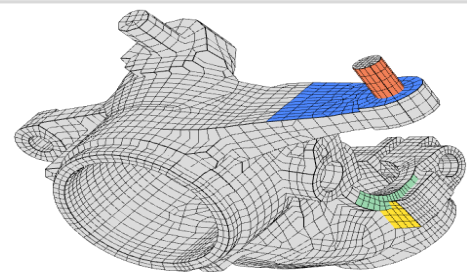
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



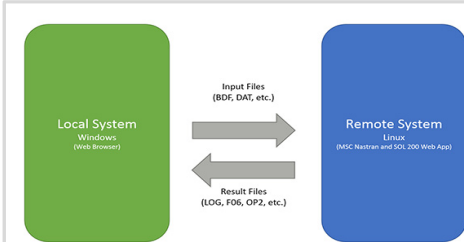
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



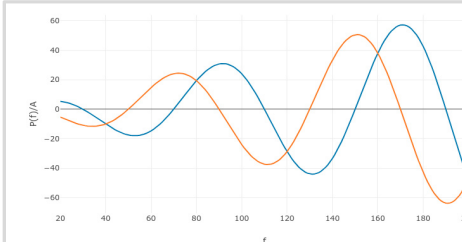
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



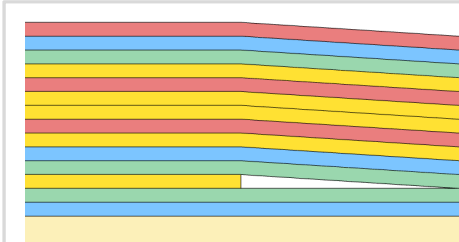
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



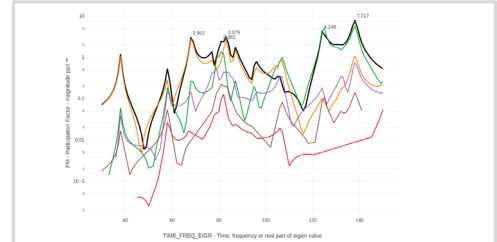
Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



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

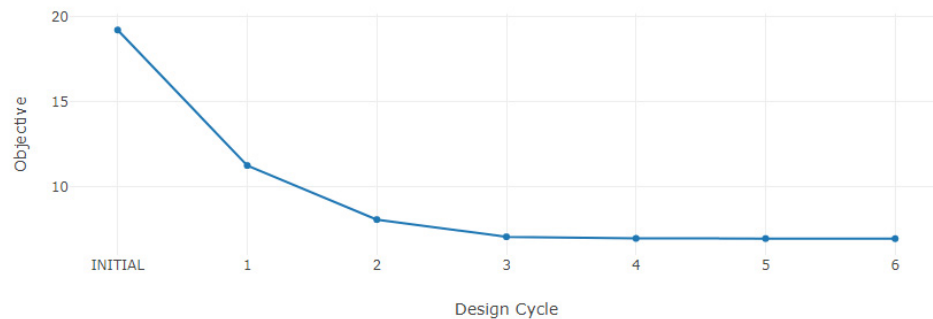
View Optimization Results

Online Plotter

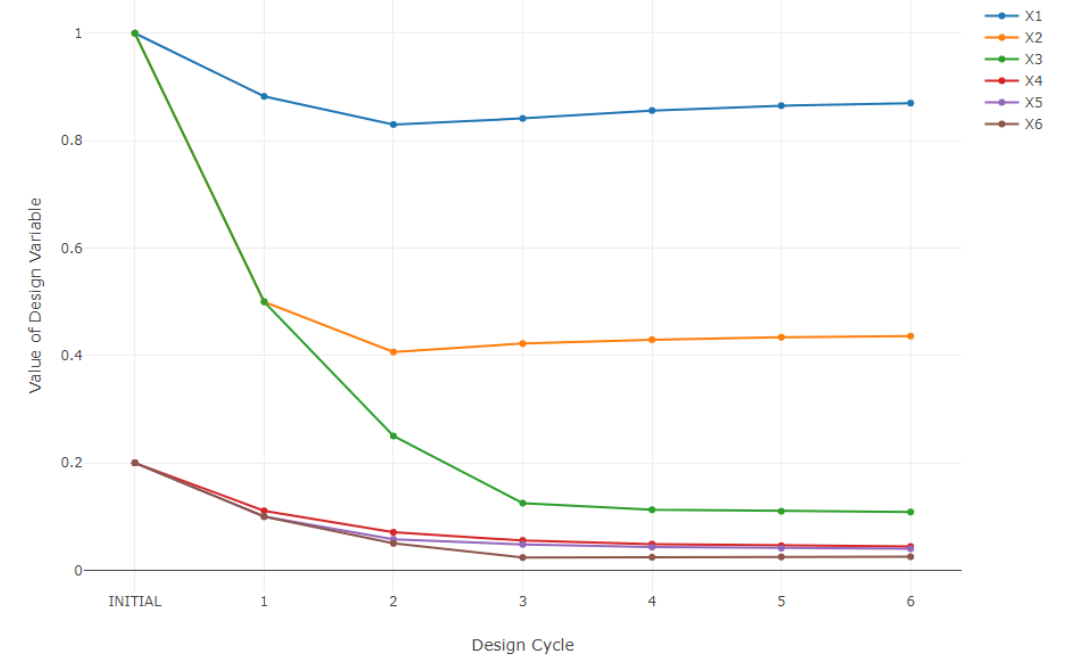
Final Message in .f06

✓ RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 6.

Objective



Design Variables



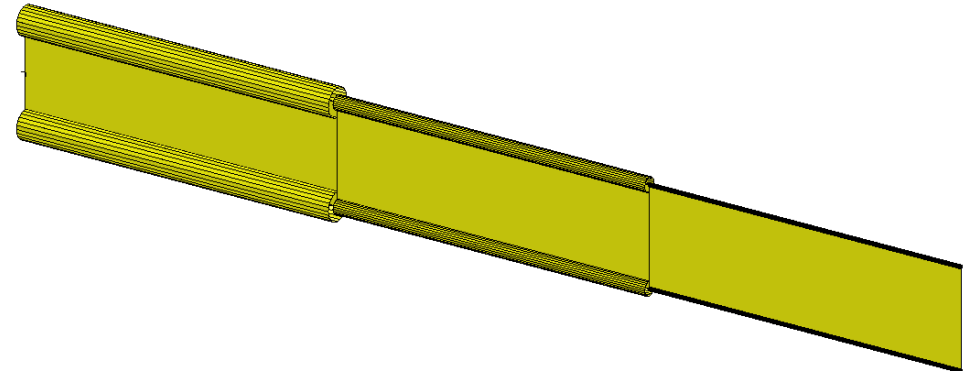
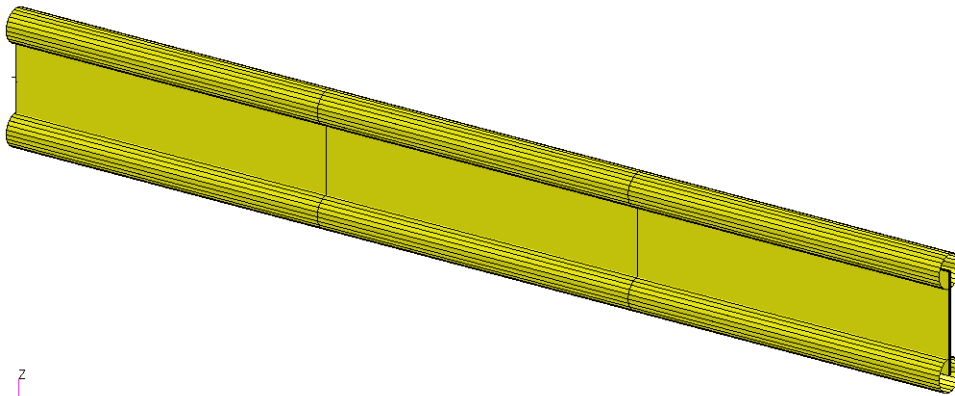
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Use the .pch file

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