Structural Optimization of a 3 Bar Truss

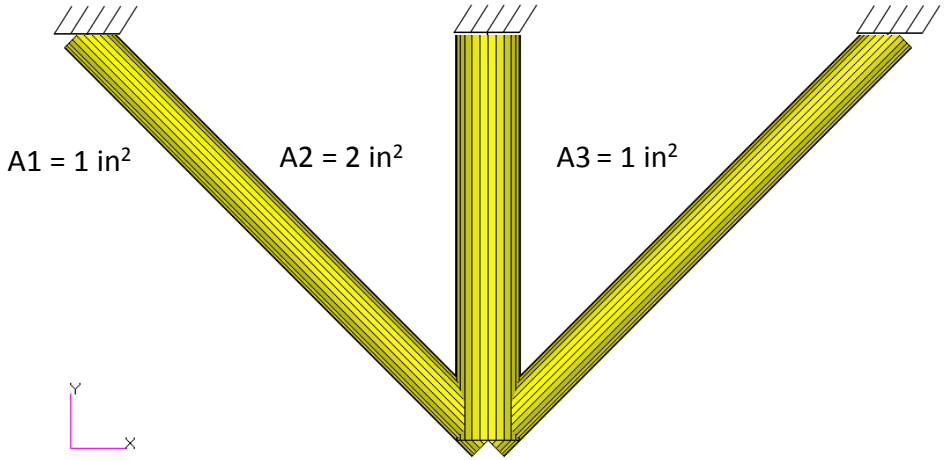
PRESENTED BY CHRISTIAN APARICIO

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

Goal: Use Nastran SOL 200 Optimization

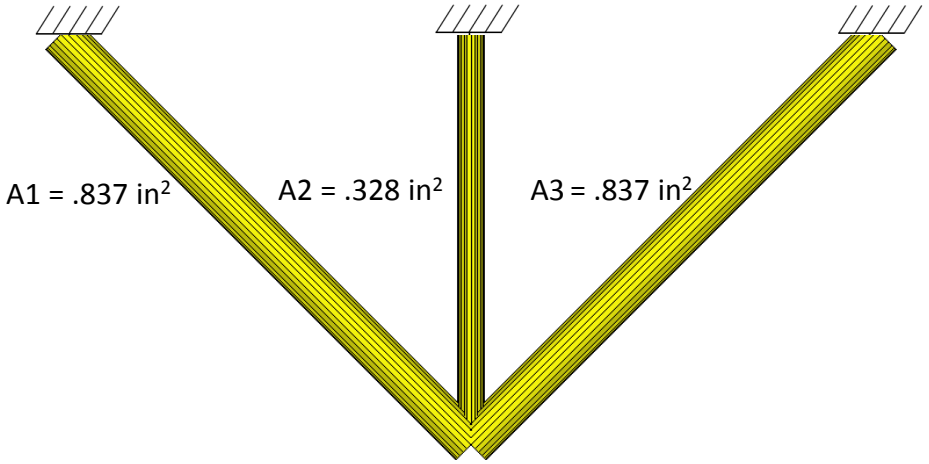
Before Optimization

- Weight: 4.82 lbs.



After Optimization

- Weight: 2.70 lbs.



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

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- Access to the SOL 200 Web App

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Details of the structural model

Three-Bar Truss

A common task in design optimization is to reduce the mass of a structure subjected to several load conditions. Figure 8-1 shows a simple three-bar truss that must be built to withstand two separate loading conditions. Note that these two loads subject the outer truss members to both compressive as well as tensile loads. Due to the loading symmetry, we expect the design to be symmetric as well. As an exercise, we'll show how to enforce this symmetry using design variable linking.

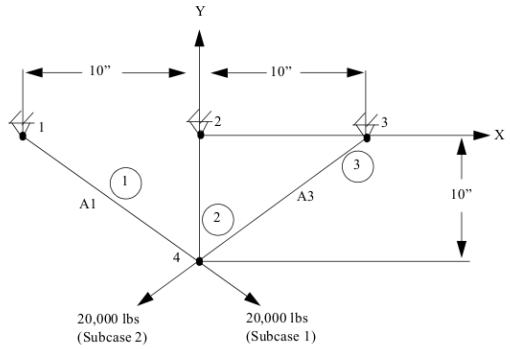
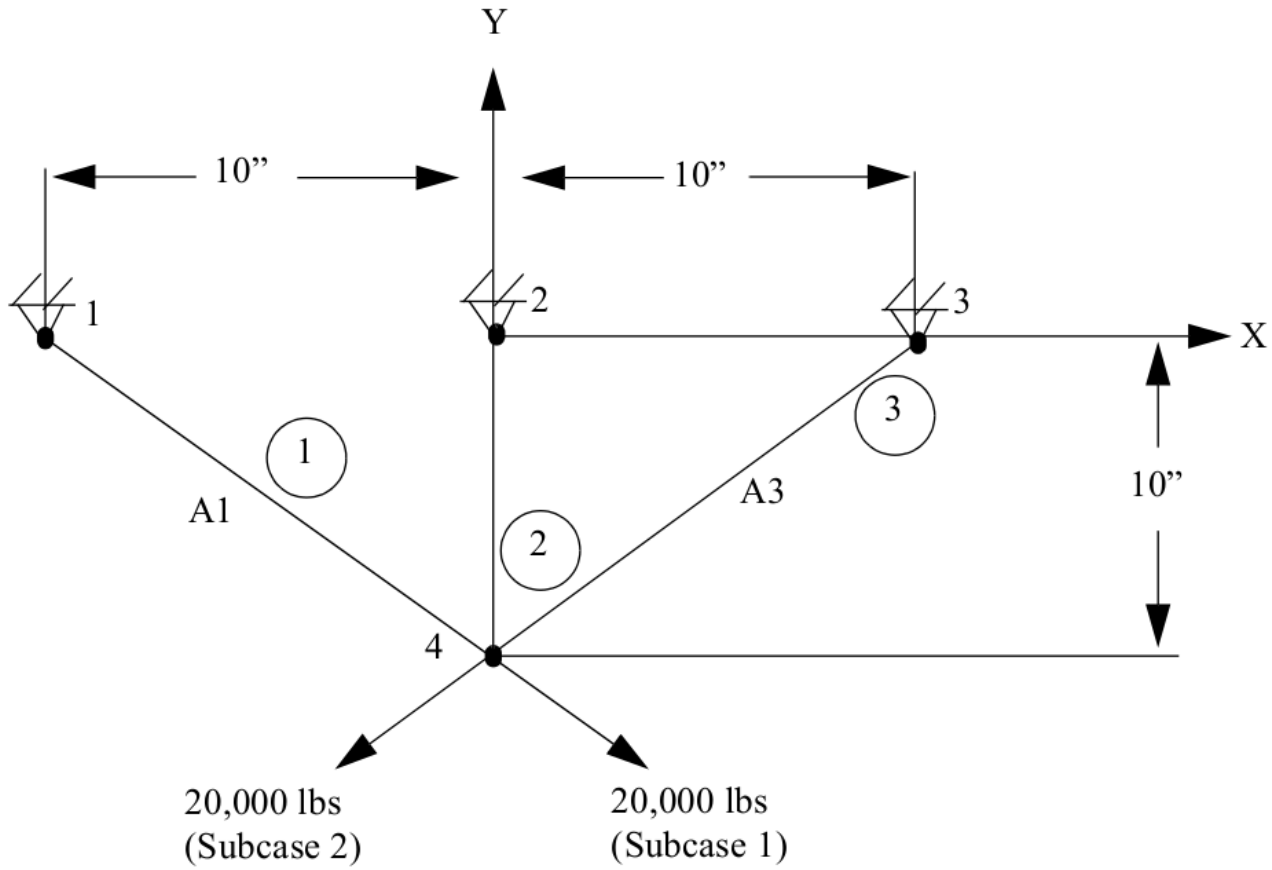


Figure 8-1 Three-Bar Truss

An important, but often overlooked consideration is that the optimization capability in MSC Nastran is multidisciplinary. That is, the final optimal design is the result of a simultaneous consideration of all analysis disciplines across all subcases. In this case, the optimal three-bar truss design will satisfy the load requirements for both statics subcases, which is to be expected. (If, for example, a normal modes or buckling subcase were to be added, the resultant design would have to not only satisfy the static strength requirements, but also constraints on eigenvalues. As an exercise you may wish to try adding an eigenvalue constraint.)

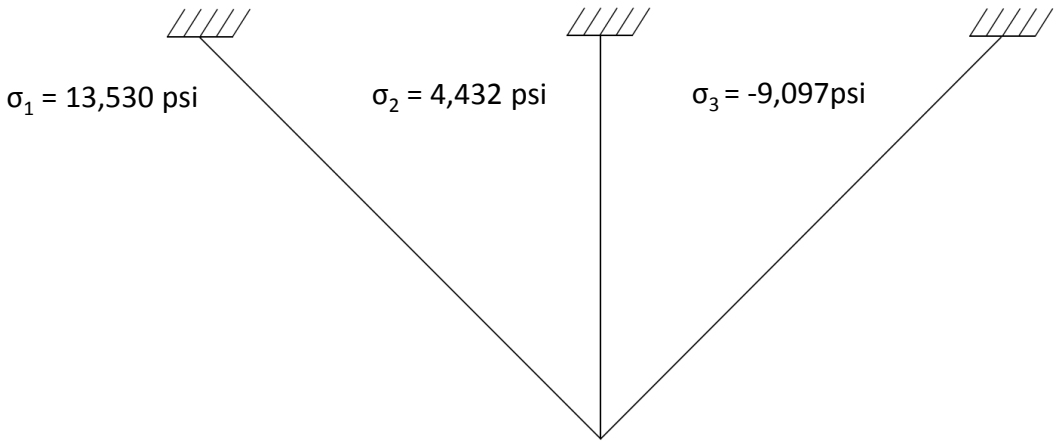
MSC Nastran Design Sensitivity and Optimization User’s Guide
Chapter 8 – Example Problems – Three Bar Truss



Details of the structural model, Continued
Axial Stresses in Model

Before Optimization

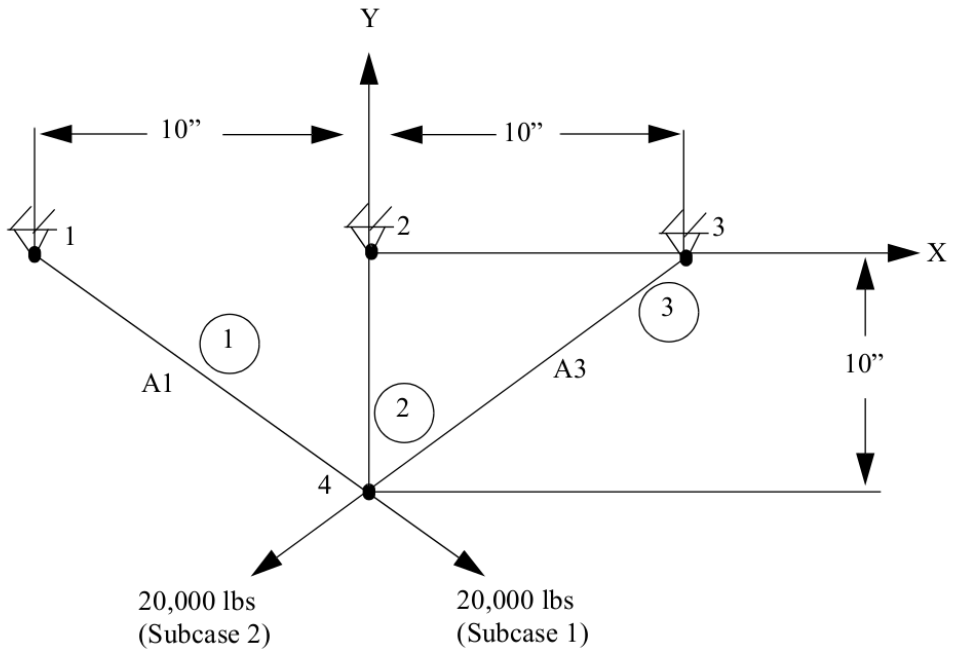
- Stresses are within the constraint
  - -15000 psi < σaxial < 20000 psi



SUBCASE 1

Optimization Problem Statement

1. Design Variables
   - x1: A | .1 < x1 < 100.
   - x2: A | .1 < x2 < 100.
   - x3: A | .1 < x3 < 100.
   - Variable Link
     - x3 = x1
2. Design Objective
   - r0: Minimize Weight
3. Design Constraints
   - r1: Axial stress in elements 1, 2 and 3
     - -15000 < r1 < 20000
   - r2: x and y displacement at node 4
     - -.2 < r2 < .2



Optimization Problem Statement

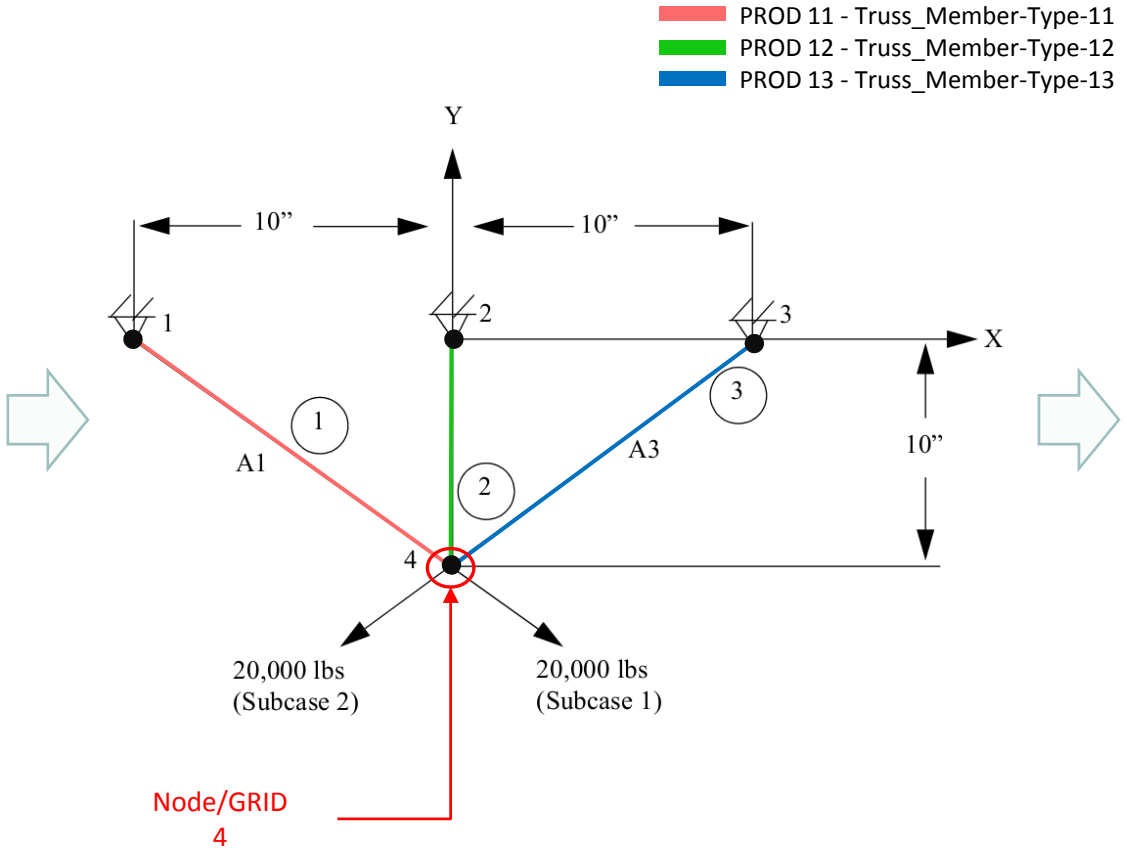
Design Variables

x1: A of PROD 11
x2: A of PROD 12
x3: A of PROD 13

.1 < x1, x2, x3 < 100.

Variable Link

x3 = x1



Responses (Outputs)

- Weight
- Volume
- Displacements
- Strains
- Stresses
- ….

Optimization Problem Statement

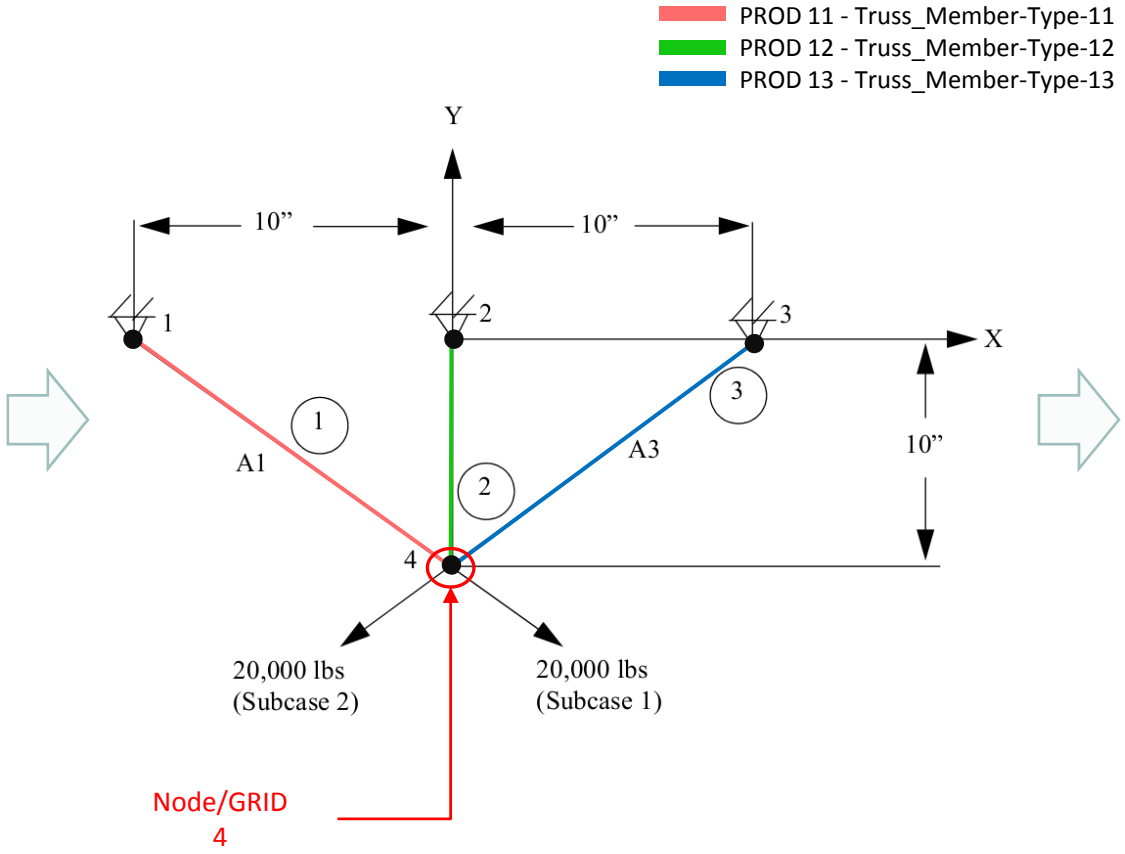
Design Variables

x1: A of PROD 11
x2: A of PROD 12
x3: A of PROD 13

.1 < x1, x2, x3 < 100.

Variable Link

x3 = x1



Design Objective

r0: Minimize weight

Design Constraints

r1: Axial stress of elements related to PROD 11, 12, 13

-15000 < r1 < 20000

r2: x and y component of displacement for node 4

-.2 < r2 < .2

Steps to use Nastran SOL 200 (Optimization)

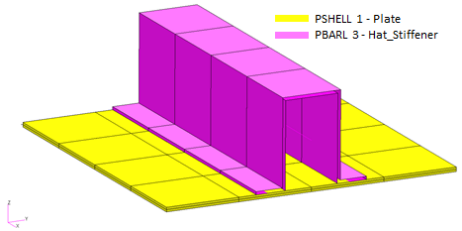
1. Start with a .bdf or .dat file
2. Use the SOL 200 Web App to:
   - Convert the .bdf file to SOL 200
     - Design Variables
     - Design Objective
     - Design Constraints
   - Perform optimization with Nastran SOL 200
3. Review optimization results
   - Online Plotter
   - Optimized structural results
4. Update the original model with optimized parameters

SOL 200 Web App Capabilities

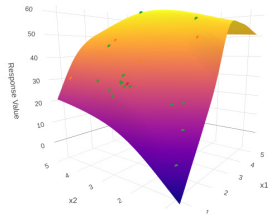
Benefits

- 200+ error validations (real time)
- Web browser accessible
- Automated creation of entries (real time)
- Automatic post-processing
- 76 tutorials

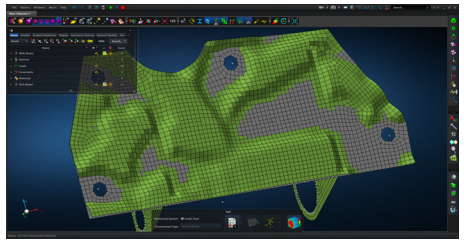
Capabilities



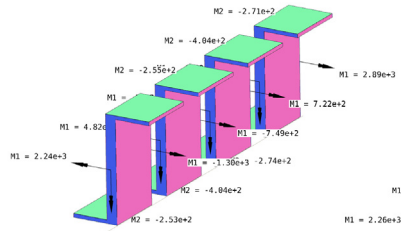
Web Apps for SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography and multi-model.



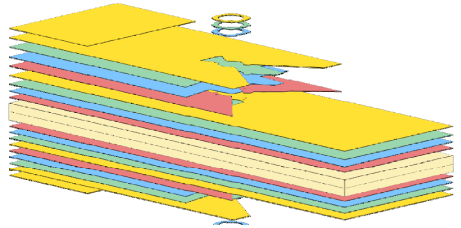
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



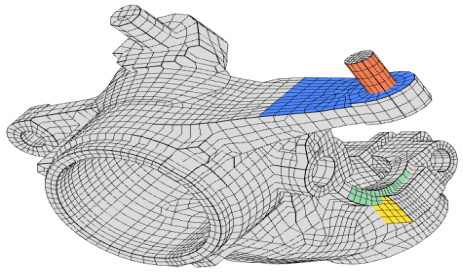
MSC Apex Post Processing Support
View the newly optimized model after an optimization



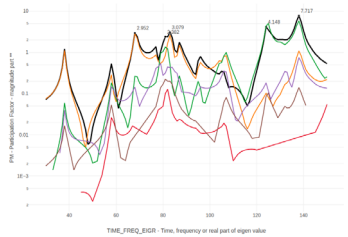
Beams Viewer Web App
Post process 1D element forces, including shear forces, moments, torque and axial forces



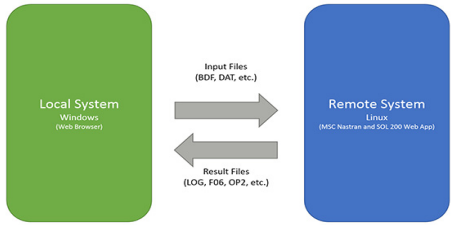
Ply Shape Optimization Web App
Spread plies optimally and generate new PCOMPG entries



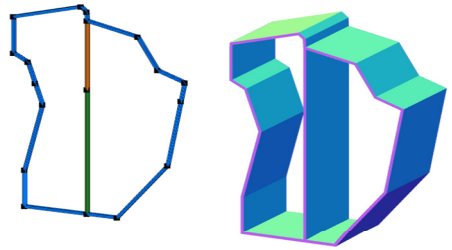
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



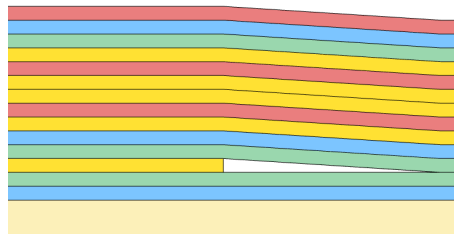
HDF5 Explorer Web App
Create XY plots using data from the H5 file



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



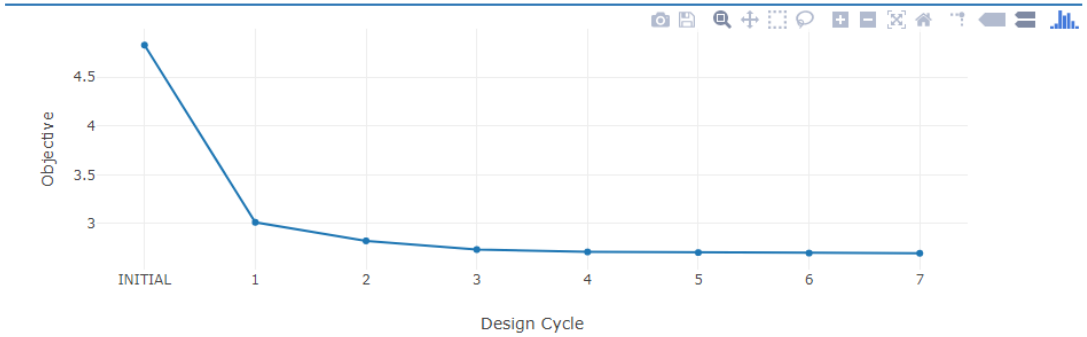
Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies

View Optimization Results
Online Plotter

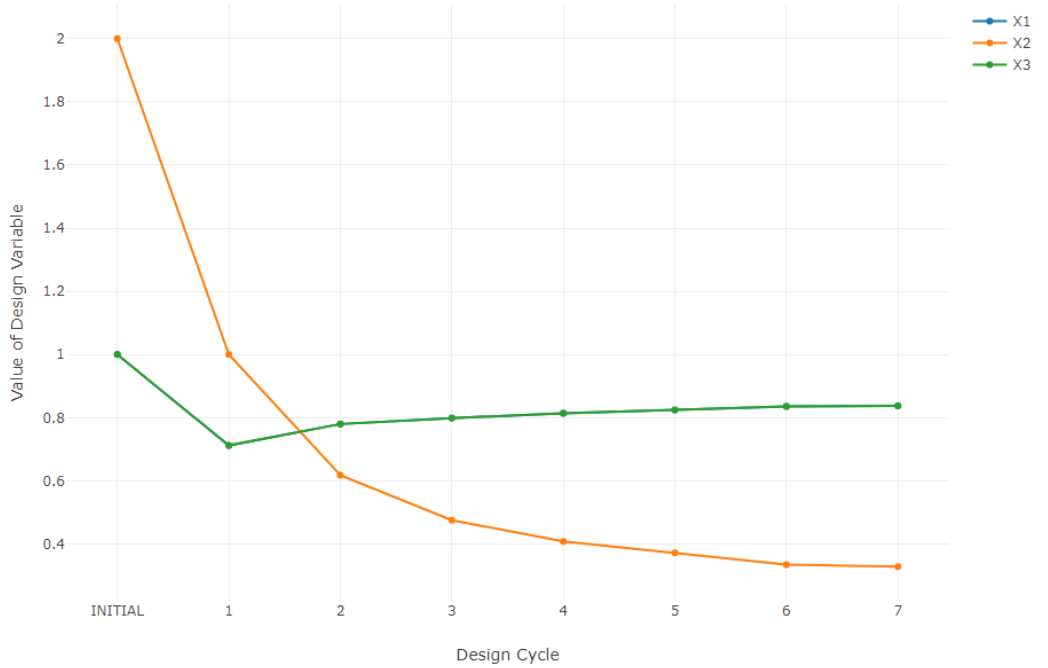
Final Message in .f06

RUN TERMINATED DUE TO HARD CONVERGENCE TO AN OPTIMUM AT CYCLE NUMBER = 7.

Objective



Design Variables



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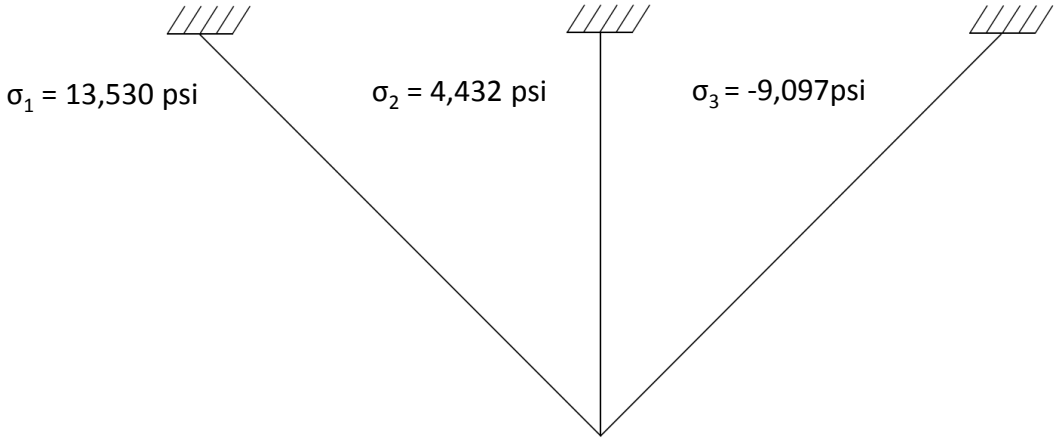

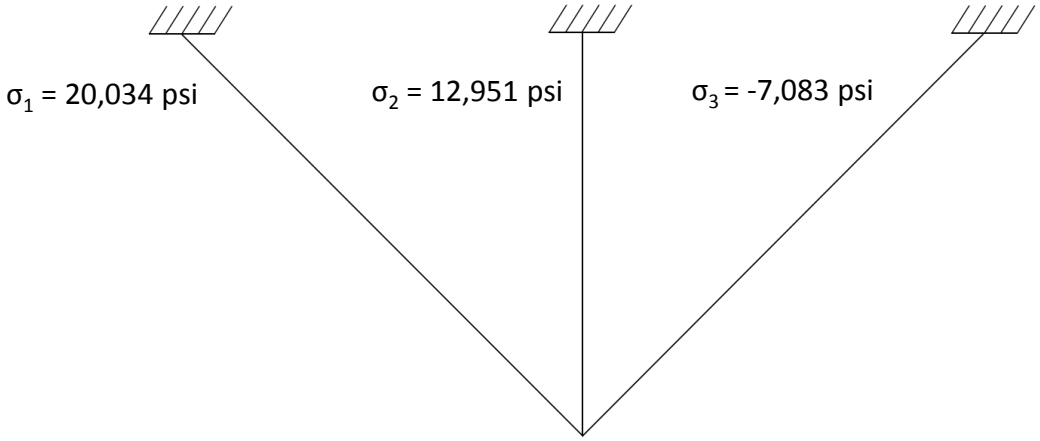

SUBCASE 1

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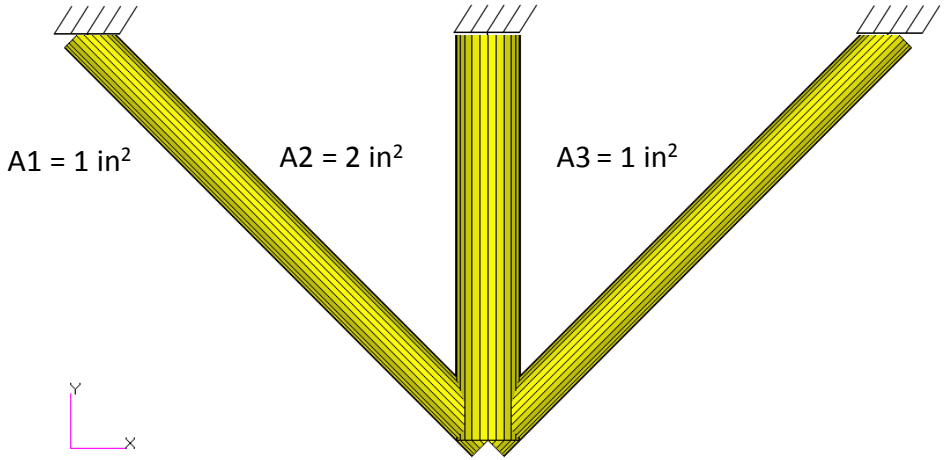

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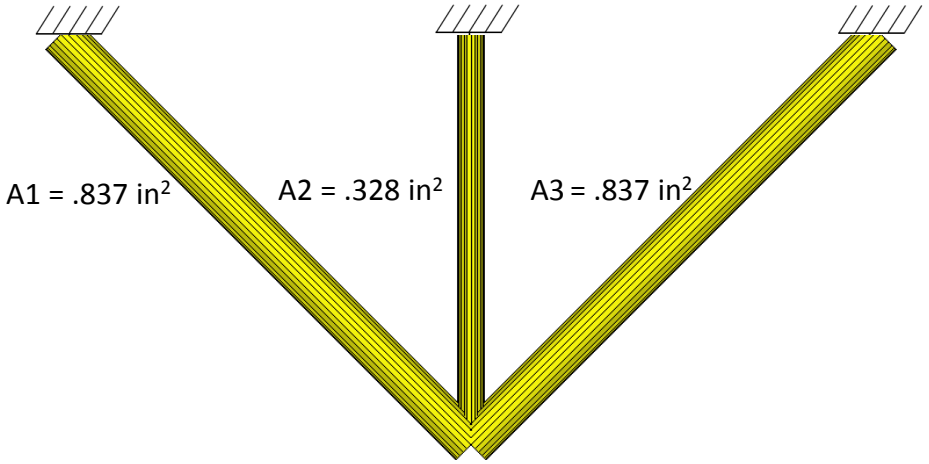

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Use the .pch file

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