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

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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 20Hz. 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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Optimization Problem Statement

**Design Variables**

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

\[ .01 < x_1, x_2, x_3 < 100. \]

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

\[ .0002 < x_4, x_5, x_6 < 2. \]

**Responses (Outputs)**

- Frequencies
- Mode shapes
- ....

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Optimization Problem Statement

**Design Variables**

- $x_1$: A of PROD 201
- $x_2$: A of PROD 202
- $x_3$: A of PROD 203

\[ .01 < x_1, x_2, x_3 < 100. \]

- $x_4$: T of PSHELL 204
- $x_5$: T of PSHELL 205
- $x_6$: T of PSHELL 206

\[ .0002 < x_4, x_5, x_6 < 2. \]

**Design Objective, Equation**

R0: Minimize $a_1 - 90$.  
where,  
$a_1$: weight of entire structure

**Design Constraints**

- r1: 1\(^{st}\) Natural frequency  
  
\[ 20 \text{ Hz} < r1 \]
Optimization Problem Statement

1. Design Variables
   - $x_1$: $A_1$ | $0.01 < x_1 < 100.$
   - $x_2$: $A_3$ | $0.01 < x_2 < 100.$
   - $x_3$: $A_3$ | $0.01 < x_3 < 100.$
   - $x_4$: $T_1$ | $0.0002 < x_4 < 2.$
   - $x_5$: $T_3$ | $0.0002 < x_5 < 2.$
   - $x_6$: $T_3$ | $0.0002 < x_6 < 2.$

2. Design Objective, Equation
   - Minimize $R_0$
     - $R_0$: $a_1$ - 90. lbs.
     - $a_1$: Weight

3. Design Constraints
   - $r_1$: 1st Natural Frequency
     - $20.$ Hz $< r_1$
Steps to use Nastran SOL 200 (Optimization)

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. Review optimization results
   - Online Plotter
   - Optimized structural results

4. Update the original model with optimized parameters
MSC Nastran SOL 200 Web App

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View Optimization Results
Online Plotter
Goal: Use Nastran SOL 200 Optimization

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

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

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Update the original structural model with optimized parameters

Use the .pch file
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