

Modal Frequency Response Analysis using MSC.Nastran

1. Theoretical background for calculations in Nastran

In this section, a very brief description is given of how the calculation of frequency response functions works with Nastran's modal frequency response analysis. Therefore, the most important equations are given in a chronological order as applied by the program.

After input of an bulk data file (*.bdf), Nastran assembles the system's mass and stiffness matrices, leading to a set of differential equations, displayed by eq. (1), already transformed in the frequency domain (damping is neglected at first).

$$\mathbf{M} \ddot{\mathbf{x}} + \mathbf{K} \mathbf{x} = \mathbf{f}(\omega) \quad (1)$$

Secondly, Nastran solves the characteristic equations (eq. (2)) for eigenvalues and computes the corresponding eigenmodes.

$$\det(\mathbf{K} - \omega^2 \mathbf{M}) = 0 \quad (2)$$

With the separation approach in eq. (3), a modal transformation[1,3] is performed, which diagonalizes the system from eq. (1), using the orthogonality properties of the eigenvectors in the modal matrix Ψ , consisting of the calculated eigenvectors.

$$\begin{aligned} \mathbf{x} &= \Psi \mathbf{q}(\omega) \\ \text{with } \Psi &= [\psi_1, \psi_2, \psi_3, \dots, \psi_N] \end{aligned} \quad (3)$$

Hereby the system, consisting of N degrees of freedom, is decoupled, leading to a system of N single-mass oscillators, with each oscillator representing an eigenmode of the system in general coordinates q_i (eq. (4)).

$$m_i \ddot{q}_i(\omega) + k_i q_i(\omega) = p_i(\omega) \quad (4)$$

Here, m_i is the modal mass, k_i the modal stiffness, and $p_i = \psi_i^T \cdot \mathbf{f}$ the modal force. With the eigenfrequencies $\omega_i^2 = k_i / m_i$, eq. (4) can be transformed to eq. (5). Furthermore, damping can be introduced by a modal damping ratio ζ_i (eq. (6), [1]).

$$\ddot{q}_i(\omega) + \omega_i^2 q_i(\omega) = \frac{p_i(\omega)}{m_i} \quad (5)$$

$$\ddot{q}_i(\omega) + 2\zeta_i \omega \dot{q}_i(\omega) + \omega_i^2 q_i(\omega) = \frac{p_i(\omega)}{m_i} \quad (6)$$

The solution of this differential equation is well known and given by eq. (7).

$$q_i(\omega) = \frac{1}{\omega_i^2 - \Omega_i^2 + i2\zeta_i \omega \Omega_i} \cdot \frac{p_i(\omega)}{m_i} \quad (7)$$

Then, the solution for the system ist a linear combination of the solutions for all oscillators (eq. (8)).

Modal Frequency Response Analysis Using Msc Nastran

B Lingard



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Table of Contents Modal Frequency Response Analysis Using Msc Nastran

1. Understanding the eBook Modal Frequency Response Analysis Using Msc Nastran
 - The Rise of Digital Reading Modal Frequency Response Analysis Using Msc Nastran
 - Advantages of eBooks Over Traditional Books
2. Identifying Modal Frequency Response Analysis Using Msc Nastran
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Modal Frequency Response Analysis Using Msc Nastran
 - User-Friendly Interface
4. Exploring eBook Recommendations from Modal Frequency Response Analysis Using Msc Nastran
 - Personalized Recommendations

- Modal Frequency Response Analysis Using Msc Nastran User Reviews and Ratings
- Modal Frequency Response Analysis Using Msc Nastran and Bestseller Lists
- 5. Accessing Modal Frequency Response Analysis Using Msc Nastran Free and Paid eBooks
 - Modal Frequency Response Analysis Using Msc Nastran Public Domain eBooks
 - Modal Frequency Response Analysis Using Msc Nastran eBook Subscription Services
 - Modal Frequency Response Analysis Using Msc Nastran Budget-Friendly Options
- 6. Navigating Modal Frequency Response Analysis Using Msc Nastran eBook Formats
 - ePub, PDF, MOBI, and More
 - Modal Frequency Response Analysis Using Msc Nastran Compatibility with Devices
 - Modal Frequency Response Analysis Using Msc Nastran Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Modal Frequency Response Analysis Using Msc Nastran
 - Highlighting and Note-Taking Modal Frequency Response Analysis Using Msc Nastran
 - Interactive Elements Modal Frequency Response Analysis Using Msc Nastran
- 8. Staying Engaged with Modal Frequency Response Analysis Using Msc Nastran
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Modal Frequency Response Analysis Using Msc Nastran
- 9. Balancing eBooks and Physical Books Modal Frequency Response Analysis Using Msc Nastran
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Modal Frequency Response Analysis Using Msc Nastran
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Modal Frequency Response Analysis Using Msc Nastran
 - Setting Reading Goals Modal Frequency Response Analysis Using Msc Nastran
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Modal Frequency Response Analysis Using Msc Nastran
 - Fact-Checking eBook Content of Modal Frequency Response Analysis Using Msc Nastran

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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