

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]).

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

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

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

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

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

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MSC Software

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Using MSC/NASTRAN Arturo O. Cifuentes, 2012-12-06 The idea of writing this book came up one night while having dinner with Ventura at the Crocodile Cafe in Pasadena This was really a joint project that could have turned into a nightmare without her support encouragement and expertise in personal computers For all these things and for tolerating my sometimes single minded attention I am very grateful to her I am also very much indebted to six good friends Paul Burrige Mladen Chargin Gary Dilley Carl Hennrich Hector Jensen and Mark Miller who read the entire manuscript of this book and made many useful suggestions I also want to thank Burt Alperson for his guidance and advice during the preparation of this book Finally I thank the Department of Civil Engineering of the University of Southern California for the support provided during the course of this project and my students of all these years for asking tough questions

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Infrastructure Risk Assessment & Management G. Schleyer, C.A. Brebbia, 2016-06-06 Infrastructure Risk Assessment Management contains selected papers presented at both the 10th International Conference on Computer Simulation in Risk Analysis and Hazard Mitigation and the 14th International Conference on Structures under Shock and Impact organized by the Wessex Institute The papers cover a variety of topics including impact and blast loading response of buildings and other structures to blast and their dynamic behaviour These are all areas of active research and general interest focused on the survivability of physical facilities and the protection of people It contains a series of research contributions essential to deepen the knowledge of how structures and materials behave

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The Shock and Vibration Digest ,1993 **Vibration Engineering and Technology of Machinery, Volume II** Rajiv Tiwari,Y. S. Ram Mohan,Ashish K. Darpe,V. Arun Kumar,Mayank Tiwari,2024-04-01 This book presents the proceedings of the XVI International Conference on Vibration Engineering and Technology of Machinery VETOMAC 2021 It gathers the latest advances innovations and applications in the field of vibration and technology of machinery Topics include concepts and methods in dynamics dynamics of mechanical and structural systems dynamics and control condition monitoring machinery and structural dynamics rotor dynamics experimental techniques finite element model updating industrial case studies vibration control and energy harvesting and MEMS The contributions which were selected through a rigorous international peer review process share exciting ideas that will spur novel research directions and foster new multidisciplinary collaborations The book is useful for the researchers engineers and professionals working in the area of vibration engineering and technology of machinery

Scientific and Technical Aerospace Reports ,1994 *Rotating Machinery, Hybrid Test Methods, Vibro-Acoustics & Laser Vibrometry, Volume 8* James De Clerck,David S. Epp,2025-08-07 Rotating Machinery Hybrid Test Methods Vibro Acoustics Laser Vibrometry Volume 8 Proceedings of the 34th IMAC A Conference and Exposition on Dynamics of Multiphysical Systems From Active Materials to Vibroacoustics 2016 the eighth volume of ten from the Conference brings together contributions to this important area of research and engineering The collection presents early findings and case studies on fundamental and applied aspects of Structural Dynamics including papers on Processing Modal Data Rotating Machinery Vibro Acoustics Laser Vibrometry Teaching Practices Hybrid Testing Reduced Order Modeling

Proceedings of the 12th International Modal Analysis Conference Dominick J. DeMichele,Society for Experimental Mechanics (U.S.),1994 **Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1** ,1991 *58th Shock and Vibration Symposium* ,1987 **A Finite Element Procedure for Calculating Fluid-structure Interaction Using MSC/NASTRAN** ,1990 **Structural Dynamics and Control Interaction of Flexible Structures** Robert Samuel Ryan,Harold N. Scofield,Harold Newton Scofield,1987 *Structural Dynamics of Electronic and Photonic Systems* Ephraim Suhir,T. X. Yu,David S. Steinberg,2011-04-04 The proposed book will offer comprehensive and versatile methodologies and recommendations on how to determine dynamic characteristics of typical micro and opto electronic structural elements printed circuit boards solder joints heavy devices etc and how to design a viable and reliable structure that would be able to withstand high level dynamic loading Particular attention will be given to portable devices and systems designed for

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