**A88-37543 Numerical calculations of the natural vibrations of turbomachine blades using the finite element method (Chislennye raschety sobstvennykh kolebanii lopatok turbomashin s ispol'zovaniem MKE).** O. V. REPETSKII, *Problemy Prochnosti* (ISSN 0556-171X), April 1988, pp. 31-36. 6 Refs.

Finite elements for calculating the vibrations of compressor and turbine rotor blades on the basis of shell theory are described. Calculations are carried out for wide-chord and cooled blades, shrouded blades, and blades with antivibration flanges. The numerical calculations are in good agreement with experimental data and other solutions.

**A88-30118 Dynamic snap-through of an elastic shell under the effect of an impulsive load (Dinamicheskoe proshchelkivanie uprugoi obolochki pod deistviem impul'snoi nagruzki).** L. S. SRUBSHCHIK, *Prikladnaia Matematika i Mekhanika* (ISSN 0032-8235), Vol. 52, Jan.-Feb. 1988, pp. 97-109. 19 Refs.

An analysis of the dynamic instability 'in the large' is carried out for an elastic shallow shell under impulsive loading and for a more general nonlinear elastic continuous conservative system with Rayleigh friction and specified initial velocity. The analysis is based on an energy approach developed for the analysis of the dynamic snap-through of a nonlinear elastic system under the effect of a stationary stepped load. The dynamic stability of the system and the critical impulsive load are determined.

**A88-29958 A method for the numerical solution of dynamic problems in shell theory (Metod chislennogo resheniia dinamicheskikh zadach teorii obolochek).** O. S. NARAIKIN, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 24, Feb. 1988, pp. 30-38. 6 Refs.

An algorithm for the numerical solution of boundary value problems in the dynamics of elastic shells of revolution is presented which is based on the construction of a matrix of fundamental solutions to the resolvent system of equations. The convergence of the algorithm is demonstrated, and estimates of its accuracy are obtained. The problem of the vibrations of a shallow spherical shell is analyzed as an example, and the results obtained are compared with the known Klein-Silvester solution.

**A87-35876 The use of an asymptotic method for solving problems in shell dynamics (Ob ispol'zovanii asimptoticheskogo metoda dlia resheniia zadach dinamiki obolochek).** P. Z. LUGOVOI and V. F. MEISH, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 23, Feb. 1987, pp. 38-44. 9 Refs.

The two-dimensional problem of the behavior of a cylindrical shell under short-term nonaxisymmetric loading is described by a mathematical model based on a hyperbolic system of Timoshenko equations. The unknowns are expanded into Fourier series in terms of the circular coordinate; a small parameter is introduced which characterizes the ratio of the shell thickness to the shell radius. The system is solved using the Laplace transform for the time coordinate and the Bubnov-Galerkin procedure for the axial coordinate. A numerical example involving a hinged cylindrical shell under nonaxisymmetric loading is presented.

**A87-46119 Optimal excitation of the resonance vibrations of elastic systems (Optimal'noe vozbuzhdenie rezonansnykh kolebanii uprugikh sistem).** A. I. KOSTOGLOTOV and L. A. SHEVTSOVA, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 23, May 1987, pp. 23-30. 8 Refs.

The Pontriagin maximum principle is applied to the analysis of the resonance vibrations of thin cylindrical shells. Expressions are obtained for the repetition rates, widths, and switching phases of the pulses exciting linear and nonlinear resonance vibrations. It is shown that optimal excitation of vibrations is accompanied by changes in the shell frequency and pulse repetition rate. The allowance for nonlinear elasticity leads to a monotonic change in the pulse repetition rate and vibration frequency. Calculation results are presented for various loading conditions.

**A87-34339 The mechanics of composite materials with local warpage in the structure (K mekhanike kompozitnykh materialov s lokal'nymi iskrivleniiami v strukture).** S. D. AKBAROV, *Prikladnaia Mekhanika* (ISSN 0032-8243), Vol. 23, Jan. 1987, pp. 119-122. 6 Refs.

An approach to the solution of problems in the mechanics of composite materials with local warpage in the structure is developed on the basis of a piecewise homogeneous body model. The approach is demonstrated for the case of an infinite elastic matrix reinforced by a single locally bent layer of a filler material; the matrix and filler materials are assumed to be isotropic and homogeneous. A specific numerical example is presented.

**A88-48318 Reconstruction of the stress strain state of a structural element from measurement results using (R-functions Vosstanovlenie napriazhenno-deformirovannogo sostoianiia elementa konstruktsii po rezul'tatam izmerenii s ispol'zovaniem R-funktsii).** V. P. LYSENKO and S. B. SKOPINTSEV, *Samoletostroenie - Tekhnika Vozdushnogo Flota* (ISSN 0581-4634), No. 54, 1987, pp. 75-79.

Methods for reconstructing the stress-strain state of structural elements from experimental data are examined which are based on a solution obtained by using the formalism of R-functions. The efficiency of approximating within a region is compared with that of approximating at a region boundary. An optimal approximation function is derived.

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# Japanese Aerospace Literature
# This month: *Dynamic Structural Analysis*

**A90-23338 Analysis of the dynamic stress concentration factor by the two-dimensional boundary element method.** HIROYUKI MATSUMOTO, TADAHARU ADACHI, YOSHITAKA KAKUHAMA, and KEIICHI FUKUZAWA, *JSME International Journal, Series I* (ISSN 0914-8809), Vol. 33, Jan. 1990, pp. 37-43. 19 Refs.

Two-dimensional impulsive stresses are analyzed by the boundary element method with the Laplace transformation and the numerical inversion using the fast Fourier transformation. The condition of the stability between the length of the element and the time step is given by the analysis. The validity of the condition is confirmed by the numerical results. Under the consideration of this condition, the dynamic stress concentration factors of the circular hole, the elliptic hole and the elliptic notch in a strip are obtained from surface forces and tangential derivatives of surface displacement. It is shown that the dynamic stress concentrations are approximately ten percent larger than the static ones.

**A90-20768 Nonstationary vibration of a rotating shaft with nonlinear spring characteristics during acceleration through a critical speed.** YUKIO ISHIDA, TAKASHI IKEDA, SHIN MURAKAMI, and TOSHIO YAMAMOTO, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, Dec. 1989, pp. 575-584. 9 Refs.

The phenomena of nonstationary oscillations of a flexible rotating shaft with nonlinear spring characteristics is investigated for the case of constant acceleration and deceleration through a critical speed of a one-half order subharmonic oscillation of forward precession. Through numerical simulations, the influence of angular acceleration, lambda, and the initial angular position, Psi-0, of a rotor unbalance on the maximum amplitude of the subharmonic oscillation is examined. The results show that: (1) the maximum amplitude depends markedly on lambda and Psi-0, (2) in order to always pass through this critical speed with finite amplitude during acceleration, an angular acceleration greater than a certain value lambda-0 is necessary, and (3) when lambda is less than lambda-0, but greater than zero, the shaft's ability to pass through this critical speed depends on Psi-0. Experiments are performed validating these theoretical results.

**A90-20767 A method of vibration analysis by use of analytical solutions together with the finite element method applications to two-dimensional acoustic problems.** YOSHIHIKO URATA and TOSHIAKI NAKAGAWA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, Dec. 1989, pp. 547-553.

A method is presented for the vibration analysis of continuous bodies. The analyzed domain is divided into several subdomains, and analytical solutions are used for the regularly shaped ones. However, the finite element method is used for the irregularly shaped subdomains. The analytical solutions are transformed into relations between generalized forces and generalized displacements at nodal points located on the boundaries of the regular subdomains. The resulting relations have the same forms as those of the finite element method. Therefore, the solutions for the regular subdomains can be joined directly to the finite element method solutions for the irregular subdomains. As examples, some two-dimensional acoustic problems are analyzed by this method. It is shown that the method has more accurate results and shorter computational time when compared to using the finite element method only.

**A89-43798 Experimental study of free vibration of clamped rectangular plates with straight narrow slits.** KOICHI MARUYAMA and OSAMU ICHINOMIYA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, June 1989, pp. 187-193.

The real-time technique of timeaveraged holographic interferometry is applied to determine the natural frequencies and corresponding mode shapes of clamped rectangular plates with straight narrow slits, and the effect of the lengths, positions, and inclination angles of slits on the natural frequencies and corresponding mode shapes is investigated. Four types of slit locations for a slit parallel with respect to the sides of a plate and a slit having various inclination angles with respect to the longer sides are considered. The natural frequencies obtained experimentally are expressed in terms of a dimensionless frequency parameter, and the results are shown graphically as a function of dimensionless slit length and inclination angle.

**A90-21601 Free vibration of a toroidal shell with elliptical cross-section.** G. YAMADA, Y. KOBAYASHI, Y. OHTA, and S. YOKOTA, *Journal of Sound and Vibration* (ISSN 0022-460X), Vol. 135, Dec. 22, 1989, pp. 411-425. 9 Refs.

An analysis is presented for the free vibration of a toroidal shell with closed or open elliptical cross-section. For this purpose, the governing equations of vibration of a toroidal shell are written as a coupled set of first order differential equations by use of the transfer matrix of the shell. Once the transfer matrix has been determined by the numerical integration of the transfer matrix equation, the frequency equations are derived in terms of the elements of the matrix. The method is applied to a toroidal shell with elliptical cross-section and the natural frequencies and the mode shapes of vibration are calculated numerically; also the effects of the cross-section of the shell on the vibration are studied.

**A90-20769 Vibration analysis of thick rotating cylindrical shells based on the two-dimensional elasticity theory.** TAKASHI SAITO, MITSURA ENDO, and KOHJI FUJIMOTO, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, Dec. 1989, pp. 585-591. 7 Refs.

Vibration analysis of infinite thick rotating cylindrical shells is described on the basis of the two-dimensional elasticity theory. Starting from the state of plane strain, the basic equation in the steady rotating state, which is used to obtain the initial stresses, is derived from Hamilton's principle, and the frequency equation, including the effect of the initial stresses due to the rotation, is formulated by Ritz's method. The numerical results for the frequencies in the nonrotating and rotating state are compared with those based on the Timoshenko-type shell theory and the available range in the latter theory is examined in terms of the thickness and rotating speed of a shell.

**A90-20766 Estimation of variance of the frequency response function in experimental modal analysis.** TAKUYA YOSHIMURA and AKIO NAGAMATSU, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, Dec. 1989, pp. 525-530. 10 Refs.

Estimation methods are presented for the variance of the frequency response function (FRF) in a vibration test. When using maximum likelihood methods, the reciprocal of the FRF's variance is used as a weighting function when system parameters are estimated with a least squares principle. The H1 and Hv estimators are the two main ways of estimating the FRF from measured input and output signals. The variance of each of these two estimators is formulated. For the H1 estimation, the variance is formulated for the cases of both single- and multiple-point excitations. The variance is expressed in terms of the FRF estimate and the coherence function. For the Hv estimation, the variance is formulated for the single-point excitation case. The validity of the formulation is confirmed by numerical simulations.

**A90-20036 Analysis of the dynamic stress intensity factor for the mixed mode crack.** HITOSHI WADA, ZENJI ANDO, and TOHRU NISHIMURA, *Proceedings of the 6th International Congress on Experimental Mechanics,* Portland, OR, June 6-10, 1988, Vol. 1 (A90-20026 07-39). Bethel, CT, Society for Experimental Mechanics, Inc., 1988, pp. 253-258. 8 Refs.

A strain gage method and a dynamic finite element method (FEM) are applied to analyze the mixed mode dynamic stress intensity factor (SIF). Analyses are carried out for plates with an inclined edge crack subjected to a three point bending in a plane of plate. A proportional extrapolation technique is used to obtain the dynamic SIF at a crack tip for each time step in the experimental analysis. In the numerical analysis by the FEM, a simple procedure proposed by authors is applied to the problem using a triangular element assumed constant strain in the element. In this work, it investigates the usefulness of the proportional extrapolation technique using values obtained by the two strain gages mounted at the crack tip on the experiment. Further, it provides the relation between the static SIF and the dynamic one for the problem on the numerical calculation.

**A90-13012 Free vibrations of a composite elliptical membrane consisting of confocal elliptical parts and having an elastically restrained boundary.** K. SATO, *Journal of Sound and Vibration* (ISSN 0022-460X), Vol. 134, Oct. 8, 1989, pp. 139-153. 7 Refs.

The paper presents a free vibration analysis of a composite elliptical membrane consisting of confocal elliptical parts. The frequency equation of the membrane subjected to an elastic force on its boundary is derived on the basis of the classical membrane theory. The lowest eigenfrequencies are calculated numerically for the four kinds of normal modes of vibration of a composite membrane consisting of two confocal elliptical parts. The special case of a homogeneous membrane is also discussed in detail.

**A89-17752 Solar array paddle with lightweight lattice panel.** H. HASHIMOTO, T. AKAEDA, M. IWAKAMI, K. MATSUMURA, and Y. KAWAI, IAF 39th International Astronautical Congress, Bangalore, India, Oct. 8-15, 1988. 9 pp. (IAF Paper 88-271).

A very efficient solar array paddle hasbeen developed for large scale satellites in communication and/or direct-broadcasting missions using higher electrical power up to ten kilowatt range with lighter weight requirements. A power-to-mass ratio of the paddle was improved by employing an ultrathin silicon solar cell of 50micron thickness and the Lightweight Lattice Panel (LLP). This paper describes the concept of the paddle configuration, details the constituent parts, and summarizes development test results.

**A89-52651 Identification of the tendon control system for flexible space structures.** YOSHISADA MUROTSU, HIROSHI OKUBO, and KEI SENDA, AIAA Guidance, Navigation and Control Conference, Boston, MA, Aug. 14-16, 1989, Technical Papers. Part 2 (A89-52526 23-08). Washington, DC, American Institute of Aeronautics and Astronautics, 1989, pp. 1186-1194. 11 Refs. AIAA Paper 89-3568

An experimental tendon control system is identified to make an accurate mathematical model for designing a good controller. The experimental tendon control system has been built for the vibration control of a flexible beam simulating Large Space Structures (LSS). This system has many natural vibration modes of low frequency. So, it needs much time to carry out a modal survey test. A proposed scheme needs time histories of responses for a very short period. First, a mathematical model of the system is developed through a finite element method (FEM). Second, unknown characteristic parameters are estimated by using an output error method. The validity of the proposed scheme is demonstrated by good agreement between the transfer functions of the experimental system and an identified model. Finally, the accuracy of the identified model is also verified by the agreement between the computed and the experimental closed-loop responses.

**A89-43799 Determination of constants of a viscoelastic model of a bonding agent.** MITSURU ENDO and TAKESHI YOSHIBA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 32, June 1989, pp. 233-239. 13 Refs.

A method for determining the constants of a three-element viscoelastic model of a bonding agent is presented. The frequency equation of a three-layer-sandwich beam with a viscoelastic bonding agent core is derived under a boundary condition requiring that both ends are free. The damped free vibration frequency and the time constant are measured experimentally, and these values are substituted into the frequency equation, resulting in the function of viscoelastic constants. Regarding the absolute value of the frequency equation as the estimation function to approach zero, and considering the viscoelastic constants as control variables, the viscoelastic constants of four kinds of bonding agents are determined by the Rosenbrock nonlinear programing method. Then, the step impulsive response of a two-layer simply-supported beam which is bound by those bonding agents is analyzed by using the three-layer beam theory. Results show the fairly large damping effect of the bonding agent.

**A89-35846 Free vibration analysis of elastic plate structures by boundary element method.** MASATAKA TANAKA, KOUJI YAMAGIWA, KENICHI MIYAZAKI, and TAKAHIRO UEDA, *Engineering Analysis* (ISSN 0264-682X), Vol. 5, Dec. 1988, pp. 182-188. 15 Refs.

This paper is concerned with an integral-equation approach to the free vibration of elastic plate structures. In the usual BIEM the eigenfrequency must be determined by means of the so-called direct search of the zero-determinant value of the system matrix. To circumvent these difficulties, a new approach is presented with its solution procedure, in which an approximate fundamental solution to the static problem is used for the formulation. The resulting set of integral equations are discretized by means of the boundary-domain-element method and reduced to a system of algebraic eigenvalue equations. The potential usefulness of the proposed method is demonstrated through some sample computations.

**A88-32189 Analytical and experimental investigations for satellite antenna deployment mechanisms.** MASAYOSHI MISAWA, TETSUO YASAKA, and SHOJIRO MIYAKE, 29th Structures, Structural Dynamics and Materials Conference, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1 (A88-32176 12-39). Washington, DC, American Institute of Aeronautics and Astronautics, 1988, pp. 116-124. 15 Refs. (AIAA Paper 88-2225).

This paper deals with the prediction of deployment dynamics, antenna vibration characteristics, and reliability evaluation related to an antenna deployment mechanism (ADM) necessary for large satellite antenna development. A statistical analysis is proposed to predict the deployment dynamics of an antenna based on the driving and friction torques of mechanical parts whose statistical distributions are fitted to normal distributions. The effect of ADM bending stiffness on antenna natural frequencies was studied analytically to establish a guideline for determination of the ADM bending stiffness. The first natural frequency of the antenna was lessened by 5 Hz due to the effect of ADM bending stiffness. A procedure is proposed to evaluate the reliability of the ADM.

**A89-39527 Boundary element analysis of cavity noise problems with complicated boundary conditions.** S. SUZUKI, S. MARUYAMA, and H. IDO, *Journal of Sound and Vibration* (ISSN 0022-460X), Vol. 130, April 8, 1989, pp. 79-96. 25 Refs.

The application of the boundary element method forthe numerical solution of noise problems inside a complexshaped cavity is considered. In particular, a new formulation for complicated boundary conditions to solve practical noise problems inside a vehicle cabin is proposed. This approach makes it possible to treat the acoustic effect of absorbent materials pasted on vibrating surfaces and the effect of leakage through an opening. Furthermore, boundary vibration velocities can be calculated with the structuralacoustic coupling effect. The sound pressure inside a linear duct is calculated to demonstrate the accuracy of the method in comparison with analytically determined solutions. Finally, the transmission of sound through a cavitybacked plate and the characteristics of sound absorption inside a sedan compartment model are discussed.

**A88-34618 Response of a damped quadrilateral cantilever plate.** O. ICHINOMIYA, K. MARUYAMA, T. IRIE, and G. YAMADA, *Journal of Sound and Vibration* (ISSN 0022-460X), Vol. 122, April 8, 1988, pp. 97-106. 8 Refs.

The steady state response of an internally damped quadrilateral cantilever plate to a sinusoidally varying point force is determined by means of the Ritz method. An arbitrary quadrilateral plate is conveniently transformed into a unit square plate by a transformation of variables. The transverse deflection of the transformed square plate can be approximately expressed in a series of beam eigenfunctions, and the driving point impedance can be derived analytically. The present method is applied to the response calculation of a skew cantilever plate driven at an arbitrary point, and natural frequencies and corresponding mode shapes are also calculated. The effects of the aspect ratio, skew angle, damping factor and location of the driving point on vibrations of a skew cantilever plate are determined quantitatively.

**A89-38081 Deployable truss beam (DTB) structural models.** YOSHINORI FUJIMORI, SEISHIRO KIBE, TATEO HOSOMURA, YASUO KUMAGIRI, HIROSHI KOMINE et al., *Proceedings of the 16th International Symposium on Space Technology and Science,* Sapporo, Japan, May 22-27, 1988, Vol. 1 (A89-38031 16-12). Tokyo, AGNE Publishing, Inc., 1988, pp. 431-436.

The Deployable Truss Beam (DTB) has seen some progress in the past two years with fabrication of truss structural models. Two kinds of models, one the all-rigid-member truss, another the tensionstrand truss have been provided for technical evaluations. Two truss models were compared in a functional test to measure static deploy/retract force. Also, static rigidity tests in axial, bending, shear and torsion modes as well as dynamic test were carried out to assess the structural integrity.

**A89-20636 Free nonlinear vibrations of stiffened rectangular plates with an initial curvature. I - Theoretical analyses of simply supported plate.** SEINOSUKE SUMI, MASAO ARITOMI, and KEN KIRIOKA, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 36, No. 416, 1988, pp. 418-426. 14 Refs.

The Marguerre equations governing the deflection of isotropic plates with small initial curvature are extended to the dynamic case of orthotropic stiffened rectangular plates. The modal equation for the nonlinear large-amplitude free vibration is established on the basis of a singlemode expression using Galerkin's method. Numerical results on square plates with various combinations of stiffening parameters, initial deflections, and inplane edge conditions are obtained.

**A89-16336 Automatic generation of equations of motion from graphic input of vibration model - A system for two-dimensional vibrations of multibody systems.** KEIICHI MARUYAMA and TAKAFUMI FUJITA, *JSME International Journal, Series III* (ISSN 0914-8825), Vol. 31, June 1988, pp. 400-408.

An automatic generation system of equations of motion was developed for two-dimensional vibrations of multibody systems. The system is written in Smalltalk-80, a language featuring a userfriendly interface for the graphic input of a vibration model; it allows users to make a variety of configurations of a vibration model on the display by choosing the vibration model elements listed in the menu with a pointing device. This language is applicable to extensive models of two-dimensional vibrations of multibody systems which contain various constraints and nonlinear elements.

**A88-50573 A vibration analysis of sandwich beams with a viscoelastic core.** YOSHIO HASHIMOTO, TADATOSHI MAWATARI, and SEINOSUKE SUMI, *Japan Society for Aeronautical and Space Sciences Journal* (ISSN 0021-4663), Vol. 36, No. 413, 1988, pp. 298-303. 11 Refs.

The vibrational response of a viscoelasticcore sandwich beam with concentrated mass and intermediate support is investigated analytically. A Laplace time transformation is used to obtain an ordinary differential equation from the partial differential equation for beam bending, and the supports and masses are modeled as undetermined concentrated forces, for which linear equations and boundary values are derived (using a one-dimensional BEM) and solved directly to determine the harmonic response. Numerical results for sample problems are presented in tables and graphs.

**A89-30770 Vibration characteristics and shape control of adaptive planar truss structures.** FUMIHIRO KUWAO, MAKOTO YOSHIHARA, SHOICHI MOTOHASHI, KENICHI TAKAHARA, and MICHIHIRO NATORI, AIAA Paper 89-1288 presented at the 30th AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics and Materials Conference, Mobile, AL, Apr. 3-5, 1989, Technical Papers. Part 3 (A89-30651 12-39). Washington, DC, American Institute of Aeronautics and Astronautics, 1989, pp. 1136-1144. 9 Refs.

The vibration characteristics of a planartruss structure are evaluated by conducting a modal survey of the function model and analyzing the mathematical model. The effectiveness of shape control for the compensation of the deformation due to the gravity force is demonstrated. The implications of the results for the adaptive planar truss structures of large space antennas are briefly discussed.

**A89-14084 Measurement of dynamic fracture toughness of ceramic material at elevated temperatures by impact test with free end bend specimen.** MASARU SAKATA, SIGERU AOKI, KIKUO KISHIMOTO, YOUSUKE FUJINO, and TOORU AKIBA, *Japan Society of Materials Science Journal* (ISSN 0514-5163), Vol. 37, Aug. 1988, pp. 910-915. 8 Refs.

A new instrumentation system was developed for the measurement of dynamic fracture toughness of ceramic materials at elevated temperatures up to 1200 C by impact tests on a free end bend, notched SiC specimen of the Charpy type. The dynamic stress intensity factor from the impact of a falling steel cylinder 6 mm in diameter and 1500 mm long was calculated by a simple formula. A series of impact tests was performed for gradually increased drop-heights. The dynamic fracture toughness values obtained in this fashion agreed satisfactorily with the results of quasi-static tests.

**A89-11689 Dynamics simulation of space structures subject to configuration change.** Y. OHKAMI, O. OKAMOTO, T. KIDA, and I. YAMAGUCHI, *Dynamics and control of large structures; Proceedings of the Sixth VPI&SU/AIAA Symposium,* Blacksburg, VA, June 29 - July 1, 1987 (A89-11651 02-18). Blacksburg, VA, Virginia Polytechnic Institute and State University, 1988, pp. 647-659. 11 Refs.

The unified matrix approach is used to develop a computer algorithm capable of simulating the dynamics of complex large space structures with variable configuration. This capability is realized through the use of a generic hinge and constraint index matrices that can handle kinetic and kinematic constraints in a unified manner. The algorithm has been successfully used to simulate a series of manipulator operations including changes in topology and constraint conditions.

**A88-49197 A modal analysis approach to nonlinear multidegrees of freedom system.** K. WATANABE and H. SATO, *ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design* (ISSN 0739-3717), Vol. 110, July 1988, pp. 410, 411. 6 Refs.

A scheme for determining the frequency response of a multipledegreesoffreedom system with multiple nonlinearities is presented in which the nonlinearities are represented by a describing function. Application of the scheme to a 3DOF system with hard springs demonstrates the significant computational savings which are possible with the method. The compliance of the nonlinear systems shows characteristics including the change of the resonant frequencies, the decrease of the peak amplitude of the compliance, and the jump phenomena of the compliance around the resonant frequency.