

MODAL METHODS FOR TRANSIENT DYNAMIC ANALYSIS IN LS-DYNA

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ABSTRACT

Modal analysis methods offer an opportunity for tremendous cost savings compared to traditional explicit approaches to transient dynamic analysis. Modal methods approximate the structural response of a body by a linear combination of pre-computed mode shapes, eliminating the need for explicit element processing. LS-DYNA's new modal analysis capability is combined with existing rigid body features to offer the additional advantage of large rigid body motion with superimposed linear modal response. This allows a portion of an LS-DYNA model to be represented by modes, while other parts of the model are treated with standard nonlinear explicit methods. LS-DYNA has also been enhanced to compute several types of modes, including eigen modes, constraint modes, and attachment modes. These modes are written to binary databases which can be viewed using LS-POST, and used as input to subsequent modal analyses. This paper introduces these new features for modal analysis, focusing on modeling procedures, input parameters, and examples of potential cost savings.

INTRODUCTION

For some applications, transient dynamic analysis can be performed very efficiently using modal methods. In contrast to standard direct methods, where the response of each node is computed independently, modal methods represent the response of the structure using a weighted combination of a set of structural mode shapes. The unknowns in modal analysis become the weights (amplitudes) of each mode. If a complete set of modes is used, i.e. the number of modes is equal to the number of degrees of freedom in the model, the method is exact and can be considered as a transformation into a set of generalized coordinates. Typically however, only a small number of modes are used, so the method becomes approximate and a substantial computational savings can be realized.

APPROACH

The underlying assumption in traditional modal analysis is linear superposition. This restricts the application of modal methods to problems of small strain and displacement. *Flexible rigid bodies* were implemented in LS-DYNA to extend modal analysis to accommodate finite rigid body motions.

Flexible Rigid Bodies

Using flexible rigid bodies, the small deformation modal response is computed in a local coordinate system at the center of mass within the rigid body. The rigid body may then undergo finite translation and rotation, together with superimposed (small) modal deformation. An LS-DYNA model may contain one or more flexible rigid bodies, as well as parts which are treated with traditional nonlinear explicit methods. For example, a flexible rigid body may be used to represent the body of a vehicle, while the suspension system may be fully nonlinear.

New Methods In Transient Analysis

**Youping Chen,James Lee,Azim
Eskandarian**



New Methods In Transient Analysis:

Transient Analysis of Power Systems Juan A. Martinez-Velasco, 2015-01-27 The simulation of electromagnetic transients is a mature field that plays an important role in the design of modern power systems Since the first steps in this field to date a significant effort has been dedicated to the development of new techniques and more powerful software tools Sophisticated models complex solution techniques and powerful simulation tools have been developed to perform studies that are of supreme importance in the design of modern power systems The first developments of transients tools were mostly aimed at calculating over voltages Presently these tools are applied to a myriad of studies e g FACTS and Custom Power applications protective relay performance simulation of smart grids for which detailed models and fast solution methods can be of paramount importance This book provides a basic understanding of the main aspects to be considered when performing electromagnetic transients studies detailing the main applications of present electromagnetic transients EMT tools and discusses new developments for enhanced simulation capability Key features Provides up to date information on solution techniques and software capabilities for simulation of electromagnetic transients Covers key aspects that can expand the capabilities of a transient software tool e g interfacing techniques or speed up transients simulation e g dynamic model averaging Applies EMT type tools to a wide spectrum of studies that range from fast electromagnetic transients to slow electromechanical transients including power electronic applications distributed energy resources and protection systems Illustrates the application of EMT tools to the analysis and simulation of smart grids Meshless Methods in Solid Mechanics Youping Chen, James Lee, Azim Eskandarian, 2006-12-31

Finite element method has been the dominant technique in computational mechanics in the past decades and it has made significant contribution to the developments in engineering and science Nevertheless FEM is not well suited to problems having severe mesh distortion owing to extremely large deformations of materials encountering moving discontinuities such as crack propagation along arbitrary and complex paths involving considerable meshings and remeshings in structural optimization problems or having multidomain of influence in multiphenomena physical problems It is impossible to completely overcome those mesh related difficulties by a mesh based method The highly structured nature of finite element approximations imposes severe penalties in seeking the solutions of those problems Distinguishing with finite element finite difference and finite volume methods meshless method discretizes the continuum body only with a set of nodal points and the approximation is constructed entirely in terms of nodes There is no need of mesh or elements in this method It does not possess the mesh related difficulties and provides an approach with more flexibility in the applications in engineering and science The meshless method started to capture the interest of a broader community of researchers only several years ago and now it becomes a growing and evolving field It is showing that this is a very rich area to be explored and has great promise for many very challenging computational problems On the one hand great advances of meshless methods have been

achieved On the other hand there are many aspects of meshless methods that could benefit from improvements A broader community of researchers can bring diverse skills and backgrounds to bear on the task of improving this method

Electromagnetic Transient Analysis and Novel Protective Relaying Techniques for Power Transformers

Xiangning Lin, Jing Ma, Qing Tian, Hanli Weng, 2015-03-02 An advanced level examination of the latest developments in power transformer protection This book addresses the technical challenges of transformer malfunction analysis as well as protection One of the current research directions is the malfunction mechanism analysis due to nonlinearity of transformer core and comprehensive countermeasures on improving the performance of transformer differential protection Here the authors summarize their research outcomes and present a set of recent research advances in the electromagnetic transient analysis the application on power transformer protections and present a more systematic investigation and review in this field This research area is still progressing especially with the fast development of Smart Grid This book is an important addition to the literature and will enhance significant advancement in research It is a good reference book for researchers in power transformer protection research and a good text book for graduate and undergraduate students in electrical engineering Chapter headings include Transformer differential protection principle and existing problem analysis Malfunction mechanism analysis due to nonlinearity of transformer core Novel analysis tools on operating characteristics of Transformer differential protection Novel magnetizing inrush identification schemes Comprehensive countermeasures on improving the performance of transformer differential protection An advanced level examination of the latest developments in power transformer protection Presents a new and systematic view of power transformer protection enabling readers to design new models and consider fresher design approaches Offers a set of approaches to optimize the power system from a microeconomic point of view

Modeling, Simulation and Optimization of Complex Processes HPSC 2015 Hans Georg Bock, Hoang Xuan Phu, Rolf Rannacher, Johannes P. Schlöder, 2017-11-16 This proceedings volume highlights a selection of papers presented at the Sixth International Conference on High Performance Scientific Computing which took place in Hanoi Vietnam on March 16-20 2015 The conference was jointly organized by the Heidelberg Institute of Theoretical Studies HITS the Institute of Mathematics of the Vietnam Academy of Science and Technology VAST the Interdisciplinary Center for Scientific Computing IWR at Heidelberg University and the Vietnam Institute for Advanced Study in Mathematics Ministry of Education The contributions cover a broad interdisciplinary spectrum of scientific computing and showcase recent advances in theory methods and practical applications Subjects covered numerical simulation methods for optimization and control parallel computing and software development as well as the applications of scientific computing in physics mechanics biomechanics and robotics material science hydrology biotechnology medicine transport scheduling and industry

Frontiers in Computational Fluid-Structure Interaction and Flow Simulation Tayfun E. Tezduyar, 2018-10-26

Computational fluid structure interaction and flow simulation are challenging research areas that bring solution and analysis

to many classes of problems in science engineering and technology Young investigators under the age of 40 are conducting much of the frontier research in these areas some of which is highlighted in this book The first author of each chapter took the lead role in carrying out the research presented The topics covered include Computational aerodynamic and FSI analysis of wind turbines Simulating free surface FSI and fatigue damage in wind turbine structural systems Aorta flow analysis and heart valve flow and structure analysis Interaction of multiphase fluids and solid structures Computational analysis of tire aerodynamics with actual geometry and road contact and A general purpose NURBS mesh generation method for complex geometries This book will be a valuable resource for early career researchers and students not only those interested in computational fluid structure interaction and flow simulation but also other fields of engineering and science including fluid mechanics solid mechanics and computational mathematics as it will provide them with inspiration and guidance for conducting their own successful research It will also be of interest to senior researchers looking to learn more about successful research led by those under 40 and possibly offer collaboration to these researchers

Space-Time

Computational Flow Analysis Tayfun E. Tezduyar, Kenji Takizawa, 2025-08-03 Space Time Computational Flow Analysis STCFA was developed in 1990 in the context of flows with moving boundaries and interfaces which is a wide class of problems that includes fluid particle interactions fluid structure interactions FSI and free surface and multi fluid flows It is a computational framework made of unconventional methods which have evolved over the years as more unconventional methods were introduced to increase its scope and accuracy It brought first of its kind solutions in many classes of problems including fluid particle interactions in particle laden flows FSI in parachute aerodynamics flapping wing aerodynamics of an actual locust ventricle valve aorta flow analysis and car and tire aerodynamics With these successes in so many classes of problems the STCFA has reached a level of remarkable sophistication scope and practical value This monograph presents for the first time a chronological catalog of STCFA methods and solutions from their development to the present Part I focuses on the STCFA in the context of finite element analysis and Part II in the context of isogeometric analysis The methods presented include complementary general purpose methods that were introduced in the evolution of STCFA All researchers working on or interested in space time computations in fluid mechanics FSI and solid mechanics including graduate students will benefit from the wealth of powerful computational methods and impressive solutions they will find in the book

New

Methods in Transient Analysis American Society of Mechanical Engineers. Winter Annual Meeting, 1992 Analysis and Design of Autonomous Microwave Circuits Almudena Suarez, 2009-02-17 Presents simulation techniques that substantially increase designers control over the oscillation in autonomous circuits This book facilitates a sound understanding of the free running oscillation mechanism the start up from the noise level and the establishment of the steady state oscillation It deals with the operation principles and main characteristics of free running and injection locked oscillators coupled oscillators and parametric frequency dividers Analysis and Design of Autonomous Microwave Circuits provides An exploration of the main

nonlinear analysis methods with emphasis on harmonic balance and envelope transient methods Techniques for the efficient simulation of the most common autonomous regimes A presentation and comparison of the main stability analysis methods in the frequency domain A detailed examination of the instabilization mechanisms that delimit the operation bands of autonomous circuits Coverage of techniques used to eliminate common types of undesired behavior such as spurious oscillations hysteresis and chaos A thorough presentation of the oscillator phase noise A comparison of the main methodologies of phase noise analysis Techniques for autonomous circuit optimization based on harmonic balance A consideration of different design objectives presetting the oscillation frequency and output power increasing efficiency modifying the transient duration and imposing operation bands Analysis and Design of Autonomous Microwave Circuits is a valuable resource for microwave designers oscillator designers and graduate students in RF microwave design **Advances**

in Natural Computation, Fuzzy Systems and Knowledge Discovery Yong Liu,Lipo Wang,Liang Zhao,Zhengtao Yu,2019-11-06 This book discusses the recent advances in natural computation fuzzy systems and knowledge discovery Presenting selected peer reviewed papers from the 15th International Conference on Natural Computation Fuzzy Systems and Knowledge Discovery ICNC FSKD 2019 held in Kunming China from 20 to 22 July 2019 it is a useful resource for researchers including professors and graduate students as well as R D staff in industry **Dynamic Description**

Technology of Fractured Vuggy Carbonate Gas Reservoirs Hedong Sun,Tongwen Jiang,Xingliang Deng,2019-04-12 Dynamic Description Technology of Fractured Vuggy Carbonate Gas Reservoirs delivers a critical reference to reservoir and production engineers on the basic characteristics of fractured vuggy gas reservoirs combining both static and dynamic data to improve reservoir characterization accuracy and development Based on the full lifecycle of well testing and advanced production decline analysis this reference also details how to apply reservoir dynamic evaluation and reserve estimation and performance forecasting Offering one collective location for the latest research on fractured gas reservoirs this reference also covers physical models analysis examples and processes 3D numerical well test technology and deconvolution technology of production decline analysis Packed with many calculation examples and more than 100 case studies this book gives engineers a strong tool to further exploit these complex assets Presents advanced knowledge in well test and production decline analysis along with performance forecasting that is specific to fractured vuggy carbonate gas reservoirs Helps readers understand the characteristics advantages disadvantages and current limitations in technology of fractured vuggy carbonate gas reservoirs Provides a bridge from theory to practice by combining static and dynamic data to form more accurate real world analysis and modeling *Electronic Design Automation for IC Implementation, Circuit Design, and Process Technology* Luciano Lavagno,Igor L. Markov,Grant Martin,Louis K. Scheffer,2017-02-03 The second of two volumes in the Electronic Design Automation for Integrated Circuits Handbook Second Edition Electronic Design Automation for IC Implementation Circuit Design and Process Technology thoroughly examines real time logic RTL to GDSII a file format used

to transfer data of semiconductor physical layout design flow analog mixed signal design physical verification and technology computer aided design TCAD Chapters contributed by leading experts authoritatively discuss design for manufacturability DFM at the nanoscale power supply network design and analysis design modeling and much more New to This Edition Major updates appearing in the initial phases of the design flow where the level of abstraction keeps rising to support more functionality with lower non recurring engineering NRE costs Significant revisions reflected in the final phases of the design flow where the complexity due to smaller and smaller geometries is compounded by the slow progress of shorter wavelength lithography New coverage of cutting edge applications and approaches realized in the decade since publication of the previous edition these are illustrated by new chapters on 3D circuit integration and clock design Offering improved depth and modernity Electronic Design Automation for IC Implementation Circuit Design and Process Technology provides a valuable state of the art reference for electronic design automation EDA students researchers and professionals

Low-Power Design Techniques and CAD Tools for Analog and RF Integrated Circuits Piet Wambacq, Georges Gielen, John Gerrits, 2007-05-08 This unique book provides an overview of the current state of the art and very recent research results that have been achieved as part of the Low Power Initiative of the European Union in the field of analogue RF and mixed signal design methodologies and CAD tools **Analytical Methods and Instruments for Micro- and Nanomaterials** Henry H. Radamson, Anders Hallén, Ilya Sychugov, Alexander Azarov, 2023-08-10 This book describes analytical instruments widely used to characterize the nanostructured materials It provides information about how to assess material quality defects the state of surfaces and interfaces element distributions strain lattice distortion and electro optical properties of materials and devices The information provided by this book can be used as a back up for material processing material design and debugging of device performance The basic principles and methodology of each analysis technique is described in separate chapters adding historic perspectives and recent developments The data analysis from simple to advanced level is introduced by numerous examples mostly taken from the authors fields of research semiconductor materials metals and oxides The book serves as a valuable guide for scientists and students working in materials science physics and engineering who wish to become acquainted with the most important analytical techniques for nanomaterials *Applied Mechanics Reviews* ,1977

Numerical Modeling in Micromechanics via Particle Methods H. Konietzky, 2002-01-01 Particle methods have seen increasing use in several engineering and scientific fields both because of their unique modelling capabilities and the availability of the necessary computational power This title focuses on their theory and application Production Engineering and Management under Fuzziness Cengiz Kahraman, Mesut Yavuz, 2010-05-18 Production engineering and management involve a series of planning and control activities in a production system A production system can be as small as a shop with only one machine or as big as a global operation including many manufacturing plants distribution centers and retail locations in multiple continents The product of a production system can also vary in complexity based on the material

used technology employed etc Every product whether a pencil or an airplane is produced in a system which depends on good management to be successful Production management has been at the center of industrial engineering and management science disciplines since the industrial revolution The tools and techniques of production management have been so successful that they have been adopted to various service industries as well The book is intended to be a valuable resource to undergraduate and graduate students interested in the applications of production management under fuzziness The chapters represent all areas of production management and are organized to reflect the natural order of production management tasks In all chapters special attention is given to applicability and wherever possible numerical examples are presented While the reader is expected to have a fairly good understanding of the fuzzy logic the book provides the necessary notation and preliminary knowledge needed in each chapter

Scientific Computing in Electrical Engineering Wilhelmus H. Schilders, E. Jan W. ter Maten, Stephan H. M. J. Houben, 2004-08-11 This book presents the proceedings of the 4th International Workshop Scientific Computing in Electrical Engineering held in Eindhoven The Netherlands from June 23-28 2002 This workshop followed three earlier workshops held in 1997 at the Darmstadt University of Technology in 1998 at the Weierstrass Institute for Applied Analysis and Stochastics and in 2000 at the University of Rostock The main topics of SCEE 2002 were computational electrodynamics circuit simulation and coupled problems The objective of the workshop which was mainly directed at mathematicians and electrical engineers was to bring together scientists from universities and industry with the goal of intensive discussions about modelling and numerical simulation of electronic circuits and electromagnetic fields A special feature was the Industry Day where distinguished speakers discussed the needs of industry in the field of computational electromagnetics and circuit simulation The book contains papers of invited and contributed talks as well as from poster presentations

Computational Fluid and Solid Mechanics 2003 K.J Bathe, 2003-06-02 Bringing together the world's leading researchers and practitioners of computational mechanics these new volumes meet and build on the eight key challenges for research and development in computational mechanics Researchers have recently identified eight critical research tasks facing the field of computational mechanics These tasks have come about because it appears possible to reach a new level of mathematical modelling and numerical solution that will lead to a much deeper understanding of nature and to great improvements in engineering design The eight tasks are The automatic solution of mathematical models Effective numerical schemes for fluid flows The development of an effective mesh free numerical solution method The development of numerical procedures for multiphysics problems The development of numerical procedures for multiscale problems The modelling of uncertainties The analysis of complete life cycles of systems Education teaching sound engineering and scientific judgement Readers of Computational Fluid and Solid Mechanics 2003 will be able to apply the combined experience of many of the world's leading researchers to their own research needs Those in academic environments will gain a better insight into the needs and constraints of the industries they are involved with those in industry will gain a

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facing Research and Design in Computational mechanics and offers new insights into the shifting the research agenda
Provides a vision of how strong basic and exciting education at university can be harmonized with life long learning to obtain
maximum value from the new powerful tools of analysis New Methods in Transient Analysis ,1992 **Computational**
Modelling of Concrete Structures Günther Meschke, Bernhard Pichler, Jan Rots, 2018-01-31 The EURO C conference series
Split 1984 Zell am See 1990 Innsbruck 1994 Badgastein 1998 St Johann im Pongau 2003 Mayrhofen 2006 Schladming 2010
St Anton am Arlberg 2014 and Bad Hofgastein 2018 brings together researchers and practising engineers concerned with
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