

**Proceedings of ASME 2021  
International Design Engineering  
Technical Conferences and  
Computers and Information in  
Engineering Conference**

**(IDETC-CIE2021)**

**Volume 9**

**17TH INTERNATIONAL CONFERENCE ON  
MULTIBODY SYSTEMS, NONLINEAR DYNAMICS,  
AND CONTROL (MSNDC)**

**August 17-19, 2021**

**Virtual, Online**

**Conference Sponsors**  
Design Engineering Division

Computers and Information  
in Engineering Division

**THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS**

Two Park Avenue \* New York, N.Y. 10016

© 2021, The American Society of Mechanical Engineers, 2 Park Avenue, New York, NY 10016, USA  
([www.asme.org](http://www.asme.org))

All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of the publisher.

INFORMATION CONTAINED IN THIS WORK HAS BEEN OBTAINED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS FROM SOURCES BELIEVED TO BE RELIABLE. HOWEVER, NEITHER ASME NOR ITS AUTHORS OR EDITORS GUARANTEE THE ACCURACY OR COMPLETENESS OF ANY INFORMATION PUBLISHED IN THIS WORK. NEITHER ASME NOR ITS AUTHORS AND EDITORS SHALL BE RESPONSIBLE FOR ANY ERRORS, OMISSIONS, OR DAMAGES ARISING OUT OF THE USE OF THIS INFORMATION. THE WORK IS PUBLISHED WITH THE UNDERSTANDING THAT ASME AND ITS AUTHORS AND EDITORS ARE SUPPLYING INFORMATION BUT ARE NOT ATTEMPTING TO RENDER ENGINEERING OR OTHER PROFESSIONAL SERVICES. IF SUCH ENGINEERING OR PROFESSIONAL SERVICES ARE REQUIRED, THE ASSISTANCE OF AN APPROPRIATE PROFESSIONAL SHOULD BE SOUGHT.

ASME shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B7.1.3). Statement from the Bylaws.

For authorization to photocopy material for internal or personal use under those circumstances not falling within the fair use provisions of the Copyright Act, contact the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923, tel: 978-750-8400, [www.copyright.com](http://www.copyright.com).

Requests for special permission or bulk reproduction should be addressed to the ASME Publishing Department, or submitted online at: <https://www.asme.org/publications-submissions/journals/information-for-authors/journalguidelines/rights-and-permissions>

ISBN: 978-0-7918-8546-8

# CONTENTS

Proceedings of ASME 2021 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference IDETC-CIE2021 Volume 9

## 17<sup>TH</sup> INTERNATIONAL CONFERENCE ON MULTIBODY SYSTEMS, NONLINEAR DYNAMICS, AND CONTROL (MSNDC)

### Computational Methods and Software Tools in Multibody Systems and Nonlinear Dynamics

- DETC2021-67164** ..... V009T09A001  
Linear Stability Analysis of a Waveboard Multibody Model With a Minimal Set of Equations  
*A. G. Agúndez, D. García-Vallejo, E. Freire, and A. M. Mikkola*
- DETC2021-67886** ..... V009T09A002  
On MBS Constraints and Projections  
*Friedrich Pfeiffer*
- DETC2021-69118** ..... V009T09A003  
Automatic Differentiation in Automatic Generation of the Linearized Equations of Motion  
*Bruce Minaker and Francisco González*
- DETC2021-69587** ..... V009T09A004  
Correlation of Reduced-Order Models of a Threaded Fastener in Multi-Axial Loading  
*Kevin Moreno, Avaneesh Murugesan, Michael Sheng, Laith Alqawasmi, Tariq A. Khraishi, and Neal B. Hubbard*
- DETC2021-72162** ..... V009T09A005  
Preliminary Study on Multibody Modeling and Simulation of an Underactuated Gripper With Differential Transmission  
*Gabriele Maria Achilli, Silvia Logozzo, Maria Cristina Valigi, and Monica Malvezzi*

### Contact and Interface Dynamics

- DETC2021-67056** ..... V009T09A006  
High Precision Contact Model for Ball Bearings With Waviness  
*Camille Jeannot, E. Sadoulet-Reboul, and S. Dufrenoy*
- DETC2021-67417** ..... V009T09A007  
Reduced Isogeometric Analysis Models for Impact Simulations  
*Tobias Rückwald, Alexander Held, and Robert Seifried*
- DETC2021-68501** ..... V009T09A008  
Nonlinear Finite Element Based Contact Modeling for Bolted Joints in Composite Laminates  
*Jielong Wang*
- DETC2021-69430** ..... V009T09A009  
Analysis and Evaluation of Piecewise Linear Systems With Coulomb Friction Using a Hybrid Symbolic-Numeric Computational Method  
*Amir Shahhosseini, Meng-Hsuan Tien, and Kiran D'Souza*

### Dynamics of Smart Structures and Systems

- DETC2021-70184** ..... V009T09A010  
A Study of a Pendulum-Like Vibration Isolator With Quasi-Zero-Stiffness  
*Yishen Tian, Dengqing Cao, and Yan Wang*
- DETC2021-72924** ..... V009T09A011  
Nonlinear Spectral Properties of Elastic Waves Propagating Along a Pantographic Metamaterial With Local Inertia Amplifiers  
*Valeria Settimi, Marco Lepidi, and Andrea Bacigalupo*

## Flexible Multibody Dynamics

- DETC2021-68162** ..... **V009T09A012**  
Absolute Nodal Coordinate Formulations for Aeroelastic Analysis of Next-Generation Aircraft  
Wings  
*Keisuke Otsuka, Shuonan Dong, and Kanjuro Makihara*
- DETC2021-68429** ..... **V009T09A013**  
Finite Element Modeling of Geometrically Exact Shell With Large Deformation and Rotation  
*Jielong Wang*
- DETC2021-70302** ..... **V009T09A014**  
Investigation of the Stability of Axially Moving Beams With Discrete Masses  
*Konstantina Ntarladima, Michael Pieber, and Johannes Gerstmayr*
- DETC2021-71078** ..... **V009T09A015**  
Dynamic Simulation of Reeving Systems With the Extension of the Modal Approach in the Axial  
Direction  
*Narges Mohammadi and José Luis Escalona*
- DETC2021-71417** ..... **V009T09A016**  
Modelling and Parameter Identification for a Flexible Rotor With Periodic Impacts  
*Stefan Holzinger, Manuel Schieferle, Johannes Gerstmayr, Manfred Hofer, and Christoph  
Gutmann*
- DETC2021-72182** ..... **V009T09A017**  
Multibody Models for Tower Vibrations With an Unbalanced Rotor  
*Simon S. Pedersen, Niclas B. Madsen, José L. Escalona, and Ole Balling*

## Keynote Lectures

- DETC2021-74773** ..... **V009T09A018**  
Steps Towards Non-Smooth Multibody Dynamics  
*Friedrich Pfeiffer*

## Lie Group Methods

- DETC2021-68186** ..... **V009T09A019**  
Singularity-Free Lie Group Integration of Multibody System Models Described in Absolute  
Coordinates  
*Andreas Müller*
- DETC2021-72057** ..... **V009T09A020**  
Dwelling on the Connection Between  $SO(3)$  and Rotation Matrices in Rigid Multibody Dynamics  
– Part 1: Description of an Index-3 DAE Solution Approach  
*Jay Taves, Alexandra Kissel, and Dan Negrut*
- DETC2021-72076** ..... **V009T09A021**  
Dwelling on the Connection Between  $SO(3)$  and Rotation Matrices in Rigid Multibody Dynamics  
– Part 2: Comparison Against Formulations Using Euler Parameters or Euler Angles  
*Jay Taves, Alexandra Kissel, and Dan Negrut*

## Machine Learning in Dynamics

- DETC2021-67070** ..... **V009T09A022**  
Enabling Artificial Intelligence Studies in Off-Road Mobility Through Physics-Based Simulation of  
Multi-Agent Scenarios  
*Aaron Young, Jay Taves, Asher Elmquist, Radu Serban, Dan Negrut, Simone Benatti, and  
Alessandro Tasora*

## Modeling, Simulation, and Validation of Vehicle Dynamics and Mobility

- DETC2021-67522** ..... **V009T09A023**  
Cross-Sensitivity Characteristics of Instrumented Wheelset Associated With Longitudinal Force and Lateral Contact Position  
*Takatoshi Hondo, Takayuki Tanaka, Shoya Kuniyuki, and Mitsugi Suzuki*
- DETC2021-68099** ..... **V009T09A024**  
Coupled Lateral and Longitudinal Control for Trajectory Tracking, Lateral Stability, and Rollover Prevention of High-Speed Automated Vehicles Using Minimum-Time Model Predictive Control  
*Shuping Chen, Huiyan Chen, Alex Pletta, and Dan Negrut*
- DETC2021-69357** ..... **V009T09A025**  
Prediction of Driver's Center of Gravity Position on a Stand-Up Type PMV Considering Intentions  
*Chihiro Nakagawa, Kosuke Sato, and Atsuhiko Shintani*
- DETC2021-69652** ..... **V009T09A026**  
POD-Based Model Order Reduction for Tire-Soil Interaction Simulations  
*Christopher C. Sullivan, Hiroki Yamashita, and Hiroyuki Sugiyama*
- DETC2021-69961** ..... **V009T09A027**  
Nonlinear Control of a Transient Inductrack System Using State Feedback  
*Ruiyang Wang and Bingen Yang*
- DETC2021-71289** ..... **V009T09A028**  
Using an SPH-Based Continuum Representation of Granular Terrain to Simulate the Rover Mobility  
*Wei Hu, Jason Zhou, Radu Serban, and Dan Negrut*

## Motion Planning, Dynamics, and Control of Robots

- DETC2021-69437** ..... **V009T09A029**  
Model-Based Design and Optimization of Passive Shoulder Exoskeletons  
*Ali Nasr, Spencer Ferguson, and John McPhee*
- DETC2021-70011** ..... **V009T09A030**  
Towards Transparent Motion Planning of Wearable Rehabilitation Exoskeletons via Model-Based Estimation  
*Jiamin Wang, David Blankenship, and Oumar Barry*
- DETC2021-70281** ..... **V009T09A031**  
An Improved Dynamic Model of the Mecanum Wheel for Multibody Simulations  
*Peter Manzl and Johannes Gerstmayr*
- DETC2021-70486** ..... **V009T09A032**  
In Search of the Jerk Element  
*Zachary P. Belyaev, Samuel N. Downes, and Philip A. Voglewede*
- DETC2021-71660** ..... **V009T09A033**  
Learning of a Basketball Free Throw With a Flexible Link Robot  
*Jannik Timke, Merlin Morlock, Daniel A. Duecker, and Robert Seifried*
- DETC2021-71797** ..... **V009T09A034**  
Multi-UAV Cooperative Transportation Using Dynamic Control Allocation and a Reinforcement Learning Compensator  
*Shuai Li and Damiano Zanotto*

## Nonlinear and Computational Dynamics Aspects in Biomechanics

- DETC2021-70112** ..... **V009T09A035**  
Simulation of a Pole Saw Assisted by a Gyroscopic Effect Device  
*Eduardo P. Okabe, Daniel L. Miletto, Milton S. Misuta, and José Luiz P. Brittes*

## Nonlinear Dynamics of Structures

- DETC2021-66831** ..... **V009T09A036**  
Boosting the Model Discovery of Hybrid Dynamical Systems in an Informed Sparse Regression Approach  
*Nico Novelli, Stefano Lenci, and Pierpaolo Belardinelli*
- DETC2021-67824** ..... **V009T09A037**  
Optimal Performance Comparison of Nonlinear Energy Sinks and Linear Tuned Mass Dampers  
*Ivan Yegorov (Egorov), Austin Uden, and Daniil Yurchenko*
- DETC2021-68529** ..... **V009T09A038**  
Geometry Optimization for Resonator Nonlinearities and Modes Controlling  
*Amal Z. Hajjaj and Nizar Jaber*
- DETC2021-68548** ..... **V009T09A039**  
A Universal Nonlinear Analyzer for Rigid Multibody Systems Based on the Efficient Galerkin Averaging-Incremental Harmonic Balance Method  
*Ren Ju, Wei Fan, and Weidong Zhu*
- DETC2021-68752** ..... **V009T09A040**  
Periodic Temperature Responses in a Thermal System Under a Periodic Heating  
*Bo Yu and Albert C. J. Luo*
- DETC2021-69248** ..... **V009T09A041**  
Modal Analysis to Interpret Localization Phenomena in Two Nonlinear Tuned Mass Dampers  
*Yuji Harata and Takashi Ikeda*
- DETC2021-70000** ..... **V009T09A042**  
Nonlinear Dynamics Simulation of Bending Deflection for Composite Laminated Plate Under Varied Temperature Using Lyapunov Exponent Parameter  
*Louay S. Yousuf*

## Optimization, Sensitivity Analysis, and Uncertainty Quantification in Dynamic Systems

- DETC2021-67585** ..... **V009T09A043**  
Multifidelity Uncertainty Quantification for Online Simulations of Automotive Propulsion Systems  
*Hang Yang, Alex Gorodetsky, Yuji Fujii, and Kon-Well Wang*
- DETC2021-68777** ..... **V009T09A044**  
Direct Sensitivity Analysis of Spatial Multibody Systems With Joint Friction Using Index-1 Formulation  
*Adwait Verulkar, Corina Sandu, Daniel Dopico, and Adrian Sandu*
- DETC2021-69604** ..... **V009T09A045**  
Evaluation of Inertial Measurement Units for Short Time Motion Tracking  
*Rene Neurauter, Peter Hergel, and Johannes Gerstmayr*
- DETC2021-69685** ..... **V009T09A046**  
Non-Linear Random Vibrations Using Second-Order Adjoint and Projected Differentiation Methods  
*Dimitrios Papadimitriou, Zissimos P. Mourelatos, and Zhen Hu*

## Time-Varying and Delay Systems

- DETC2021-68257** ..... **V009T09A047**  
An Alternative Formulation for Modeling Self-Excited Vibrations of Drillstring With PDC Bits  
*Kaixiao Tian, Emmanuel Detournay, and He Zhang*
- DETC2021-71028** ..... **V009T09A048**  
A Simple Approach for the Computation of Lyapunov-Floquet Transformations for the Mathieu Equation  
*Ashu Sharma*