Dr. Anish Kumar

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Birsa Institute of Technology, Sindri, Dhanbad,
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Research Interests

Nonlinear dynamics and vibrations, Bifurcation Analysis, Structural Dynamics, Reduced Order Modelling, Approximate Mathematical Methods in Engineering, Theory of Plates and Shells, Bi-linear Oscillators, Fluid Structure Interaction, and Modelling and Simulation of MEMS & NEMS.

Education

2012(Jan) - 2017 **Ph.D, Mechanical Engineering**, *Indian Institute of Technology Kanpur, India.*

2009 - 2011 **M.Tech, Mechanical Engineering**, *Indian Institute of Technology Kanpur, India.*

2005 - 2009 **B.Sc. Engineering, Mechanical Engineering**, *Muzaffarpur Institute of Technology, Muzaffarpur (B.R.A. Bihar University, Muzaffarpur), India.*

Postdoctoral Experience

December 2017 - March 2021 **Postdoctoral Research Fellow**, *Department of Mechanical Engineering*, Technion-IIT, Haifa, Israel.

Industry Experience

April 2021 -August 2021 **Structures and Design Engineer**, Skyroot Aerospace Privet Limited, Hyderabad.
Telangna, India.

Teaching Experience

January 2023 -Present **Assistant Professor**, BIT Sindri,, Dhanbad.
Jharkhand, India.

September 2021 -December 2022 **Assistant Professor**, JK Lakshmipat University, Jaipur.
Rajsthan, India.

Journal Publications

Anish Kumar*, Yuli Starosvetsky and Jayaprakash K.R (2022) *Analysis of transition regions of bi-linear, parametrically driven, two-oscillator model: Resonant excitation in the neighborhood of non-similar NNMs.* **International Journal of Non-Linear Mechanics** , 145,104074.

Anish Kumar*, Sovan Lal Das, Pankaj Wahi and Krzysztof Kamil Zur (2022) *On the stability of thin-walled circular cylindrical shells under static and periodic radial loading* **Journal of Sound and Vibration**, 527, 116872.

Anish Kumar* and Yuli Starosvetsky (2021), *Analysis of transition regions in the parametrically forced system of bi-linear oscillators: Resonant excitation in the neighborhood of similar modes.* **Journal of Sound and Vibration**, 515, 116435.

Anish Kumar, Sovan Lal Das and Pankaj Wahi (2017), *Effect of radial loads on the natural frequencies of thin-walled circular cylindrical shells.* **International Journal of Mechanical Sciences**, 122, 37-52.

Anish Kumar, Sovan Lal Das and Pankaj Wahi (2015), *Instabilities of thin circular cylindrical shells under radial loading*, **International Journal of Mechanical Sciences**, 104, 174-189.

Manuscript under review

Anish Kumar and Oded Gottlieb, *The influence of nonlinear viscoelastic damping on the bifurcation structure of clamped axisymmetric circular microplates subjected to combined parametric and external electridynamic excitation* (under review).

Manuscript under preparation

Anish Kumar and Oded Gottlieb, *Internal resonant interactions of electrodynamically excited asymmetric circular plate modes.* (Manuscript under preparation).

Anish Kumar, Yuli Starovetsky, *Stability analysis of the bilinear oscillator with piece-wise linear stiffness, damping and amplitude of parametric excitation using method of averaging* (Manuscript under preparation).

Anish Kumar, Sovan Lal Das and Pankaj Wahi , *Effect of fluid loading on the dynamic behavior and stability of circular cylindrical shells* (Manuscript under preparation).

Conferences

Anish Kumar, Oded Gottlieb (2023), *The response of nonlinear circular viscoelastic panels to electrodynamic excitation*, Third International Nonlinear Dynamics Conference (NODYCON 2023), Rome, June 18-22, 2023

Anish Kumar, Yuli Starosvetsky (2022), *Analysis of parametric instabilities of two-oscillator bi-linear model through the resonant order reduction in the vicinity of similar nonlinear normal modes*, 10th European Nonlinear Dynamics Conference (ENOC 2020+2), 17-22 July 2022, Lyon, France.

Anish Kumar, Sovan Lal Das and Pankaj Wahi (2015), *Effect of Radial Loading on the Beam Mode Vibration of Circular Cylindrical Shells*, Indian National Conference on Applied Mechanics (INCAM), 13-15 July 2015, IIT Delhi, India.

Anish Kumar, Sovan Lal Das and Pankaj Wahi (2013), *Effect of radial hydrostatic loads and boundary conditions on the natural frequencies of thin walled circular cylindrical shells*, 11th International Conference on Vibration Problems (ICOVP), Lisbon, Portugal, 9-12 September 2013.

Anish Kumar, Sovan Lal Das and Pankaj Wahi (2011), *Dynamic buckling of thin walled cylindrical shells subjected to fluctuating radial loads*, 21st International Conference on Structural Mechanics in Reactor Technology 2011 (SMiRT 21), 6-11 November 2011, New Delhi, India.

Doctoral thesis

Title **Dynamics and Instabilities of Thin-Walled Circular Cylindrical Shells under Radial loading.**

Supervisors Prof. Pankaj Wahi and Dr. Sovan Lal Das

Abstract Present study explores the dynamic behavior of the thin-walled circular cylindrical shells. Toward this end, first the equations of motion of the thin shell with predominant radial deflection has been developed, which are consistent with assumptions taken. Additional terms have been identified in shell equations, which have mostly been neglected in the existing studies and also ascertained their importance in predicting the correct buckling pressure. Donnell shell theory is very popular among researchers to study the static and dynamic behavior of the shells. But the present study has shown that Donnell shell theory does not predict correct buckling pressure for lower circumferential wave number. For being consistent with assumptions, strain-displacement relation according to Flügge-Luré-Byrne shell theory has been used. Stability charts have been obtained for cylindrical shell subjected to uniform dynamic radial pressure. These stability charts are obtained in the plane of forcing parameters, like the static component of the pressure, the amplitude and frequency of the fluctuating component of the pressure have been presented which can serve as design guideline for shells subject to fluctuating radial loads. The variations of the natural frequencies of the circular cylindrical shells subjected to uniform radial and hydrostatic pressure. For hydrostatic pressure, we have studied with and without incorporation of the fluid inertia. Along with these studies, we have also studied the post-buckling behavior of the cylindrical shells. For predicting post buckling behavior, the nonlinear terms, which play important role in the analysis, are identified.

Master thesis

Title **Dynamic buckling of thin walled circular cylindrical shells under radially fluctuating pressure.**

Supervisors Prof. Pankaj Wahi and Dr. Sovan Lal Das

Abstract We investigated the dynamic buckling of a thin walled circular cylindrical shell for infinite length under radially fluctuating pressure. First we did a thorough study of all the existing shell theories. We calculated the static buckling of a circular cylindrical shell of infinite length using these shell theories and compared the results with FEA results using ABAQUS. It was noticed that only a few shell theories are more consistent and give results which have good agreement with FEA results. Flugge-Lure-Byrne shell theory is found out to be the most consistent. Parametric instability of infinitely long cylindrical shell subjected to time varying radially applied pressure has been studied.

Postdoc Project: 1

Title **Dynamics and stability of electrodynamically excited nonlinear viscoelastic circular micro and nanoplates.**

Supervisor Prof. Oded Gottlieb

Abstract Electrodynamically micro and nanoplates are widely used for Micro/Nano-Electro-Mechanical Systems (MEMS/NEMS), such as micropumps, microphones and capacitive micromachined ultrasonic transducers. Vibrating circular plates are widely used in various sensors and actuators such as capacitive micromachined ultrasonic transducers (CMUTs). In large amplitude operation, geometric nonlinearities and material damping have a significant effect on the dynamic behavior of the micro and nanoplates. We study the response of the clamped circular plates. Towards this end, first we derive the general nonlinear dynamic equation for the clamped plates which have linear viscous and nonlinear viscoelastic damping. Nonlinear von-Karman strain-displacement relations along with a linear Voigt- Kelvin viscoelastic constitutive law is used to consistently derive nonlinear damping properties of a general asymmetric configuration. We also deduce the limiting case for an axisymmetric configuration. We apply a Galerkin ansatz to the initial boundary value problem to yield a coupled set of nonlinear ordinary differential equations for both axisymmetric and asymmetric configurations. Using the dynamic equations for the axisymmetric configuration, we determine the effect of DC voltage, gap between plates and bi-axial residual stresses on the plate's maximum deflection, its natural frequencies, and pull-in voltage. We verify both the equilibrium and periodic dynamic response with results available in the literature (analytical and experiments) to find an excellent agreement for both micro and nanoplates. We study the effect of nonlinear viscoelastic damping on the plate bifurcation structure by numerical integration of the modal dynamical system. Based on optimized parameters determined from a graphene nanoplate, we study primary, parametric, internal and combination resonances for different forcing parameters. The results clearly show that the influence of nonlinear damping is essential for high mode dynamics. Specifically, for parametric and combination resonances where negligible nonlinear damping can lead sto spurious unbounded response.

Postdoc Project : 2

Title **Parametric Instabilities of Bilinear Oscillators.**

Supervisor Prof. Yuli Starosvetsky

Abstract The bilinear oscillator is a simple model showing a highly nonlinear system with resistant forces act differently and depend on the direction of movements. It is very important to understand the dynamics and stability of the bilinear system, as they appear in numerous engineering applications, e.g., interlocking blocks, train carriages, mortarless structures, cracked beam are few of them. Oscillations in the bilinear medium can cause fractures and be detrimental to the stability of the system, so the motivation for the investigation of its dynamics will usually be to avoid the instabilities caused by bi-linearity. The study of bilinear oscillators has attracted researchers in the field of applied mechanics for several decades. In the present work, we find analytical solutions for the instabilities of the Bi-linear systems using Action-Angle (A-A). Results obtained using the approximate method are in very good agreement with numerical results. First, we find Non-linear Normal Modes (NNM) using Poincare maps for complicated bilinear systems. Using information from NNM (e.g., initial conditions, frequency, etc), we reduce two coupled bilinear oscillators into a single bilinear oscillator. We consider only the anti-phase mode for the present analysis. The reduced single bilinear oscillator has been solved using the developed approximate method using A-A variables. Other methods, e.g., averaging method, harmonic balance methods have also been employed and found they are in very good agreement with numerical results of the exact models [1]. Results have been obtained for two types of bilinear systems, e.g., symmetric coupled bilinear and unsymmetric coupled bilinear systems for two oscillators.

Academic Projects

Stress analysis in the crane structures

Crane's elements are subjected to different kind of stresses at different level during working. Finite element method has been employed to study the behavior of crane structure when subjected to loads. A MATLAB code was developed for this purpose, stress and strain responses were studied.

Linear and Non-linear FEM code for the general bar and beam

Linear and nonlinear FEM code has been developed to study the behavior of bar and beam under axial and transverse load, respectively. Various type of elements have been used to observe the convergence of the solutions and obtained results are verified with the results obtained using FEA software like ABAQUS.

Parametric stability analysis of the circular cylindrical shell under radially fluctuating pressure.

Using Donnell nonlinear shell theory, stability charts has been developed numerically using MATLAB.

Elastic wave propagation in a thin circular ring

A theoretical model of the thin circular ring was developed, using MAPLE and MATLAB numerical solutions were found to study the shear wave and bending wave in the ring.

Derivation of drag force on a cylindrical particle moving in a thin sheet of viscous fluid.

A mathematical model has been developed for a cylindrical particle moving in thin sheet of the viscous fluid and then the expression for the drag force acted on the cylindrical particle during movement has been calculated analytically.

Study of the dynamics of the cytoskeleton inside the biological cell membrane.

Stability of spherical vesicle membrane under external pressure.

Relevant Courses

Post Graduate — Continuum Mechanics, Theory of Elasticity, Wave Propagation in Solid, Stability of Structures, Finite Element Method, Calculus of Variation, Approximate Methods in Engineering Mathematics, Nonlinear Finite Element Method, Advance Dynamics and Vibrations, Vibrations of Continuous System, Vibration Control, Nonlinear Vibration, Mechanics of Biological Membrane.

Teaching Assistantship

Spring 2009, Spring 2010 and Fall 2012	ME251, ***Machine Design and Graphics***, IIT Kanpur, India.
Fall 2010	ME621, ***Introduction to Solid Mechanics***, IIT Kanpur, India.
Spring 2012	ME222A, ***Nature and Properties of Materials Lab***, IIT Kanpur, India.
Fall 2013 and Fall 2015	ESO209, ***Dynamics***, IIT Kanpur, India.
Spring 2013	ESO204, ***Mechanics of Solids***, IIT Kanpur, India.
Fall 2014	ME321A, ***Advance Mechanics of Solids***, IIT Kanpur, India.
Spring 2014	ME354A, ***Vibration and Control Lab***, IIT Kanpur, India.

Spring 2015 ME627A, ***Nonlinear Vibration***, IIT Kanpur, India.

Tutorship

Summer 2014 ESO204, ***Mechanics of Solids***, IIT Kanpur, India.

Computer Skills

Languages Fortran, C.

Packages Matlab, ABAQUS, ANSYS, Maple.

Operating System UNIX(Linux), Windows.

Professional Activities

Reviewer Nonlinear Dynamics.
Mechanics Based Design of Structures and Machines.
Archive of Applied Mechanics.
Journal of Applied and Computational Mechanics.

Awards, Scholarships, Grants, and Academic Achievements

2022 **Summer Faculty Research Fellow,** Indian Institute of Technology Delhi, India, .

2019 **Technion Post-doctoral Fellowship,** Technion- Israel Institute of Technology, Haifa, Israel, .

2017 **Technion Post-doctoral Fellowship,** Technion- Israel Institute of Technology, Haifa, Israel, .

2013 **Travel Grant for ICOVP 2013,** Lisbon, Portugal from DRPG, IIT Kanpur, .

2013 **Letter of Appreciation** from Student Gymkhana, IIT Kanpur (For serving as a coordinator of Prayas, a Gymkhana club), .

2012 **PhD Fellowship** from MHRD, Government of India, .

2009 **M.Tech Fellowship** from MHRD, Government of India, .

2009 **B.Sc. (Engineering) First Class with Distinction**, .

2009 **GATE 2009,** Score 670 correspoding to 99.04 percentile, All India Rank 218., .

References

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