Department of APPLIED MATHEMATICS

GENERAL INFORMATION

The Department of Applied Mathematics was founded in 1947 and originally had the name "Department of Theoretical and Mathematical Physics". This name has long been associated with the names of outstanding scientists who were the first heads of the department such as Naum Il'ich Akhiezer, Israel Markovich Glasman, Vladimir Logvinovich Rvachev, and whose scientific activity was directly related to the problems of theoretical and mathematical Physics. In 1981, the department was renamed and became the Department of Applied Mathematics.

Since January of 2022, the Head of the Department is Vyacheslav Burlayenko.
Today, the staff of the Department consists of ***19*** members among which

Professors: ***5***
Senior academic staff: ***8***
Service personnel: ***3***
Doctoral students: ***2***
Postdoctoral fellow: ***1***

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EDUCATIONAL ACTIVITY

The Department of Applied Mathematics offers about twenty high-quality courses per year. The courses can be roughly divided into three categories:

- Basic Higher Mathematics courses for the Bachelor's Programme in Applied Mathematics, Computer Science, Mechanical Engineering and Transport, and others (more than fifteen different specialties with a variety of educational programs in Higher Mathematics);

Complements of Higher Mathematics for the Master's Programme in Applied Mathematics;

and

- Advanced Mathematics course for the Doctoral Programme in Applied Mathematics;

SCIENTIFIC ACTIVITY

Research activity is mainly focused on applied mathematics problems in physics, mechanics and engineering. And formally, research can be divided into the following, in general, interconnected areas:

I. Finite element method in Continuum Mechanics Problems

Finite element analysis is a standard tool in industrial applications, and commercial packages such as ABAQUS, ANSYS, etc., make it easily accessible to engineers and researchers. However, complex problems arising e.g. from multi-physics phenomena require a deep understanding of the mathematical foundation of problems, as well as the development and application of finite element modeling for their solution.

Research problems:

- 3-D free and forced vibrations of Functionally Graded Material plates and sandwich panels including those subject to temperature or other external environment conditions;
- 3-D dynamic analysis of sandwich panels with partially damaged face sheet to core interface with and without taking into account contact conditions between detached surfaces;
- Fracture analysis of Functionally Graded Material planar plates under thermal shock using Virtual Crack Closure Technique;
- 3-D homogenization analysis of Honeycomb Foam-Filled sandwich panels;

SCIENTIFIC ACTIVITY

- Fracture analysis related to Debonding onset and propagation in sandwich panels subjected to static and dynamic loading using cohesive elements and XFEM approach;
- Analytical-numerical estimations of the Energy Release Rate and the interface strength in sandwich fracture specimens;
- High fidelity simulations of Friction Stir Welding process using both the Coupled Eulerian Lagrangian (CEL) approach and the Smoothed Particle Hydrodynamics (SPH) method.

Personnel

V. Burlayenko, Head of the Depart., Associate Professor, Ph.D.

V. Veretelnik, Associate Professor, Ph.D.

SCIENTIFIC ACTIVITY

II. R-functions method in Continuum Mechanics Problems

R-functions theory in combination with the Ritz method allows developing semi-analytical and meshless computation algorithms for solving various problems in Mechanics.

The group guided by Professor Lidiya Kurpa conducts research in dynamics and stability of homogeneous, laminated and functionally graded plates and shallow shells of regular and complex geometry using R-functions and the Ritz method.

Research problems:

- Free vibration analysis of composite laminated and functionally graded material plates and shallow shells of regular and complex geometry including those subject to the thermal environment;
- Free vibration analysis of composite laminated and functionally graded plates and shallow shells resting on elastic foundations;
- Buckling analysis of composite laminated and functionally graded material plates and shells of regular and complex geometry;
- Geometrically nonlinear free vibration analysis of composite laminated and functionally graded plates of regular and complex geometry;
- Free vibration analysis of composite laminated and functionally graded plates and shallow shells of variable thickness;

SCIENTIFIC ACTIVITY

Personnel


L. Kurpa,
Prof. D.Sc.


H. Timchenko,
Prof. PhD


H. Linnik,
Prof. PhD


K. Ljubicka,
Assoc Prof. PhD


I.Morachkovska,
Assoc Prof. PhD


T. Shmatko
Postdoc PhD

- Parametric vibrations composite laminated plates of complex shape, and vibrations and buckling of small-scale composite plates of complex shape based using the modified couple stress theory

Personnel


O. Mazur, Assoc. Professor, Ph.D.

SCIENTIFIC ACTIVITY

III. Nonlinear normal modes in Dynamics of n-DOF nonlinear systems

Studies in the field of regular and chaotic dynamics of non-linear systems, in particular, problems of vibration damping by means of nonlinear absorbers, problems of stability of motion, problems of vibro-impact oscillations, nonlinear dynamics of systems with limited power supply, analysis of resonance behavior etc. are performed using NNMs approach

Research problems:

- Studying regular dynamics and resonance behavior in a system of two coupled pendulums under a magnetic field and random oscillations;
- Research of regular and chaotic dynamics of systems with a limited power supply having pendulum or mass-spring absorbers;
- NNMs in nonlinear systems modeling cracks and other violations of their internal structure;
- Nonlinear normal vibration modes in rotor dynamics;
- Direct and inverse problems encountered in vibro-impact oscillations of discrete systems including elastic systems with a vibro-impact absorber;
- Analysis of chaos onset in discrete mechanical systems with several equilibrium positions;
- Dynamic analysis of n-DOFs mechanical systems with essentially nonlinear vibration damping;

SCIENTIFIC ACTIVITY

- Stability of regular or chaotic post-buckling vibration of elastic shells;

Personnel

Yu. Mikhlin
Professor, D.Sc.

Y. Surganova
Doctoral Student

Y. Lebedenko
Doctoral Student

- Regular and chaotic dynamics of smooth/discontinuous nonlinear systems

Personnel

L. Dzyubak, Assoc. Professor, Ph.D.

SCIENTIFIC ACTIVITY

Scientific outcomes in selected publications:

Burlayenko, V.N., Sadowski, T., Altenbach, H. (2022) Efficient free vibration analysis of FGM sandwich flat panels with conventional shell elements, *Mechanics of Advanced Materials and Structures*, 29:25, 3709-3726

Kurpa, L., Awrejcewicz, J., Mazur, O., Morachkovska, I. (2022) Free vibrations of small-scale plates with complex shape based on the nonlocal elasticity theory. *Acta Mech* 233, 5009–5019

Shmatko, T., Kurpa, L. & Awrejcewicz, J. (2022) Dynamic analysis of functionally graded sandwich shells resting on elastic foundations. *Acta Mech* 233, 1895–1910

Mazur, O., Awrejcewicz, J. (2022) The nonlocal elasticity theory for geometrically nonlinear vibrations of double-layer nanoplate systems in magnetic field. *Meccanica* 57, 2835–2847

Surganova, Y.E., Mikhlin, Y.V. (2022) Localized and non-localized nonlinear normal modes in a system of two coupled pendulums under a magnetic field. *International Journal of Non-Linear Mechanics*, 147, 104182

Awrejcewicz, J., Sypniewska-Kamińska, G., Mazur, O. (2022) Analysing regular nonlinear vibrations of nano/micro plates based on the nonlocal theory and combination of reduced order modelling and multiple scale method. *Mechanical Systems and Signal Processing*, 163, 108132

Burlayenko, V.N. (2021) A continuum shell element in layerwise models for free vibration analysis of FGM sandwich panels. *Continuum Mechanics and Thermodynamics* 33, 1385–1407

SCIENTIFIC ACTIVITY

Kurpa, L., Tkachenko V., Linnik, A. (2021) Buckling of laminated plates subjected to non-uniform distributed in-plane force, *Mechanics Based Design of Structures and Machines*, 49:8, 1145-1156

Awrejcewicz, J, Kurpa, L, Shmatko, T. (2021) Application of the R-functions in free vibration analysis of FGM plates and shallow shells with temperature dependent properties. *Z Angew Math Mech*. 101:e202000080

Mikhlin, Y.V., Rudnyeva, G.V. (2021) Stability of similar nonlinear normal modes under random excitation. Nonlinear Dyn 103, 3407–3415

Awrejcewicz, J., Kudra, G. & Mazur, O. (2021) Parametric vibrations of graphene sheets based on the double mode model and the nonlocal elasticity theory. *Nonlinear Dyn* 105, 2173–2193

Awrejcewicz, J., Kudra, G. & Mazur, O. (2021) Double mode model of size-dependent chaotic vibrations of nanoplates based on the nonlocal elasticity theory. *Nonlinear Dyn* 104, 3425–3444

Zafar, A.A., Awrejcewicz, J., Mazur, O., Riaz, M.B. (2021) Study of composite fractional relaxation differential equation using fractional operators with and without singular kernels and special functions. *Adv Differ Equ* 2021, 87

Burlayenko, V.N., Sadowski, T. (2020) Free vibrations and static analysis of functionally graded sandwich plates with three-dimensional finite elements. *Meccanica* 55, 815–832

Mazur, O, Kurpa, L, Awrejcewicz, J. (2020) Vibrations and buckling of orthotropic small-scale plates with complex shape based on modified couple stress theory. *Z Angew Math Mech.* 100:e202000009

SCIENTIFIC ACTIVITY

Mikhlin, Y., Onizhuk, A. & Awrejcewicz, J. (2020) Resonance behavior of the system with a limited power supply having the Mises girder as absorber. *Nonlinear Dyn* 99, 519–536

Mazur, O., and Awrejcewicz, J. (2020) Nonlinear Vibrations of Embedded Nanoplates Under In-Plane Magnetic Field Based on Nonlocal Elasticity Theory. ASME. *J. Comput. Nonlinear Dynam*. 15(12): 121001

Burlayenko V.N., Pietras D., Sadowski T. (2019) Influence of geometry, elasticity properties and boundary conditions on the Mode I purity in sandwich composites. *Composite Structures* 223, 110942

Ghazaryan D., Burlayenko V. N., Avetisyana A., Bhaskar A. (2018) Free vibration analysis of non-uniform cross-section and axially functionally graded beams using the differential transform method. *Journal of Engineering Mathematics* 110 97–121

Kurpa, L., Timchenko, G., Osetrov, A., Shmatko, T. (2018) Nonlinear vibration analysis of laminated shallow shells with clamped cutouts by the R-functions method. *Nonlinear Dyn* 93, 133–147

Awrejcewicz J., Kurpa L., Shmatko T. (2018) Linear and nonlinear free vibration analysis of laminated functionally graded shallow shells with complex plan form and different boundary conditions. International *Journal of Non-Linear Mechanics*, 107, 161-169

Burlayenko V.N., Altenbach H., Sadowski T., Dimitrova S.D., Bhaskar A. (2017) Modelling functionally graded materials in heat transfer and thermal stress analysis by means of graded finite elements. *Applied Mathematical Modelling* 45 422–438

SCIENTIFIC ACTIVITY

Plaksiy, K.Y., Mikhlin, Y.V. (2017) Interaction of free and forced nonlinear normal modes in two-DOF dissipative systems under resonance conditions. *International Journal of Non-Linear Mechanics*, 94, 281–291

Avramov, K.V., Mikhlin, Y.V. (2013) Review of applications of Nonlinear Normal Modes for Vibrating Mechanical Systems. ***Applied Mechanics Reviews***, 65(2), 020801

Mikhlin, Y. V., and Avramov, K. V. (2011) Nonlinears Normal Modes for Vibrating Mechanical Systems. Review of Theoretical Developments. ***Appl. Mech. Rev.*** 63(6): 060802

International Experience

2022-2023, Research Fellow at Mid Sweden University within the KK foundation programme, Sundsvall, Sweden (K. Lyubitska)

2019-2020, Research Fellow at Politechnika Łódzka within the programme OPUS 14, National Science Center Poland, Lodz, Poland (O. Mazur)

2019, DAAD Grant no. 91734200 for 3-month Research at Otto-von-Guericke University Magdeburg, Magdeburg, Germany (V. Burlayenko)

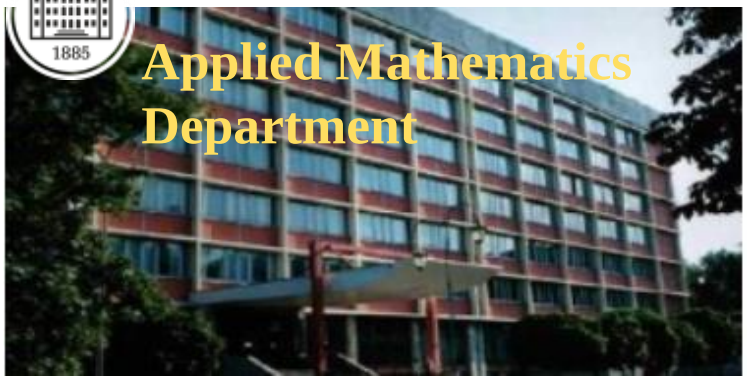
2017-2019, Principal Investigator in POLONEZ 2 project no. UMO-2016/21/P/ST8/00790 at the Lublin University of Technology, under the Marie Skłodowska-Curie grant agreement No. 665778, Lublin, Poland (V. Burlayenko)

2015-2016, Erasmus Mundus exchange programme ACTIVE, grant No. AC/TG2/SOTON/PD/23/2015 at University of Southampton, Southampton, UK (O. Mazur, V. Burlayenko and L. Dzyubak)

INTERNATIONAL COLLABORATION

Institution	Country	Events
Department of Solid Mechanics, Lublin University of Technology	Poland	Collaborative research, academic mobility (V. Burlayenko, Yu. Mikhlin)
Department of Automation, Biomechanics and Mechatronics, Lodz University of Technology	Poland	Collaborative research, academic mobility (L. Kurpa, L. Dzyubak, O.Mazur)
Department of Technical Mechanics, Otto von Guericke University Magdeburg	Germany	Collaborative research, academic mobility (V. Burlayenko)
Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia	Italy	Collaborative research, academic mobility (L. Kurpa, T. Shmatko)

PROPOSAL TO COOPERATE



- **Education**
- **Research**
- **Open-minded about alternative topics and the direction of collaborative work**