

CONTENT

NONLINEAR DYNAMICS OF DISCRETE SYSTEMS

1.	L. Akulenko, D. Leshchenko, Y. Zinkevich, A. Rachinskaya. Response-optimal deceleration of the rotation of a symmetric free rigid body in a resistive medium.	9
2.	I.V. Andrianov, V.I. Olevs'kyy. Critical re-examination of Adomian's decomposition and homotopy perturbation methods in nonlinear mechanics.	15
3.	K.V. Avramov, O.V. Borysiuk. Bifurcations of elastic rotors in journal bearings.	21
4.	J. Awrejcewicz, L.P. Dzyubak. Chaos caused by hysteresis in 2-DOF rotor vibrations.	27
5.	A.B. Batkhin. Families of periodic solutions of Hill's problem.	33
6.	I.I. Blekhman, N.P. Yaroshevich. Transient regimes in systems with inertial excitation of oscillations.	39
7.	I. Bula. On some chaotic mappings in symbol space.	45
8.	A. Bychkov. Investigation of stability with respect to part of variables in hybrid automata.	50
9.	G. Chechin, G. Bezuglova, P. Goncharov. Existence and stability of discrete breathers with different symmetries in 2D square lattices.	56
10.	T.N. Dragunov, R.E. Kondrashov, A.D. Morozov. On visualization of resonance structures in dynamical systems with two degrees of freedom.	62
11.	A.G. Grechnev, A.S. Kovalev, M.L. Pankratova. Hysteresis phenomenon in ferro/antiferro layered system.	67
12.	E.Zh. Harutyunyan. Investigation of the nonlinear oscillation of the passenger car suspension.	73
13.	K.R. (Stevanović) Hedrih, L. Veljović. The kinetic pressures of the gyro-rotor eigen shaft bearings and rotators.	78
14.	K.R. (Stevanović) Hedrih, V. Raičević, S. Jović. The phase portrait of the vibro-impact dynamics of two mass particle motions along rough circle.	84
15.	I. Ivanov. Stability for a class of systems with uncertain structure.	90
16.	W. Jarzyna, M. Augustyniak, J. Warmiński, M. Bocheński. Model based identification of active beam composite structure - application MRAS algorithm.	96
17.	A.A. Kireenkov. Coupled dry friction model for the heavy disk slid with spinning on the rough plane.	102
18.	Yu. Kivshar. Nonlinear physics and energy localization in periodic systems.	108
19.	Yu.A. Kosevich, L.I. Manevitch. Irreversible transfer of vibration energy in linear and nonlinear coupled parametric systems.	109
20.	P.V. Krot. Dynamics and diagnostics of the rolling mills drivelines with non-smooth stiffness characteristics.	115
21.	V.V. Kulyabko. Nonlinear structural dynamics in XXI century: specified models, vibro-comfort buildings, nonlinear dampening devices.	121
22.	O.G. Kyselova, I.A. Nastenکو. Estimation of heart rate complexity of behavior using different methods of nonlinear dynamics.	125
23.	V.A. Lykah, E.S. Syrkin. Nonlinear rotational modes in molecular chains.	129
24.	G. Martynenko. Method of detuning from resonance modes for rotors in active magnetic bearings with nonlinear force characteristics.	135
25.	M. Merkuryev. Constructing an optimal Lyapunov function for investigation of stability of linear fuzzy hybrid automaton.	141
26.	Yu.V. Mikhlin, A.A. Klimenko. Nonlinear normal modes in pendulum systems.	146

27.	Yu.V. Mikhlin, G.V. Rudnyeva. Construction of transient in mechanical systems.	152
28.	I. Mukherjee. Stability analysis of periodic solutions for a class of fractionally damped system of engineering interest.	158
29.	E.D. Pechuk, T.S. Krasnopolskaya. Reconstruction of the third order dynamical systems from signals.	164
30.	N.V. Perepelkin, Yu.V. Mikhlin. Nonlinear normal modes of forced vibrations in rotor systems.	170
31.	V.N. Pilipchuk. On algebraic structures induced by U-turns and non-invertible time substitutions.	176
32.	S.N. Polukoshko, S.V. Sokolova, V.Y. Jevstignejev. Impact vibration absorber of pendulum type.	177
33.	A.Yu. Shvets, V.A. Pechernyi. New aspects of chaotic dynamics of pendulum systems with a limited power-supply.	183
34.	A.Yu. Shvets, V.A. Sirenko. Chaos and hyperchaos in deterministic nonideal hydrodynamic systems.	189
35.	V.V. Sidorenko. Some remarks about quasi-steady dynamics.	195
36.	V.V. Smirnov, L.I. Manevitch. Limiting phase trajectories and dynamical transitions in the nonlinear periodic systems.	200
37.	M.M. Tkachuk, A.V. Grabovsky, M.A. Tkachuk. An approach to identification of impact interaction model for a vibroimpact system.	207
38.	Y. Ueda. At the very instant when the author came across an inexperienced behavior.	213
39.	V.G. Verbitskii, V.G. Khrebet, N.O. Velmagina. The bifurcation set for a two-axes vehicle model with the non-linear dependence of slipping forces.	219
40.	M. Wiercigroch. Grazing induced bifurcations in impacting systems.	225
41.	A. Zotov. Oscillation of systems which have force-displacement characteristics with rectangular loops of hysteresis.	226

NONLINEAR DYNAMICS OF DISTRIBUTED SYSTEMS

1.	H. Altenbach, V.A. Eremeyev. On the oscillations of nonlinear magnetoelastic solids.	230
2.	H. Altenbach, V.A. Eremeyev, M.M. Ievdokymov. On the impact on a plate made of hyperelastic foam.	236
3.	M. Amabili, Y. Kurylov, R. Garziera. Polynomial versus trigonometric expansions for nonlinear vibrations of shells with different boundary conditions.	242
4.	K.V. Avramov. Nonlinear dynamics of traveling waves of circular plates with cutouts.	248
5.	K.V. Avramov, H. Strel'nikova, I. Breslavsky. Nonlinear dynamics of plates and shallow shells interacting with moving fluid.	250
6.	J. Awrejcewicz, L. Kurpa, O. Mazur. Investigation of the parametric vibration of the orthotropic plates subjected to periodic in plane forces by multi-modal approximation and R-functions method.	256
7.	M. Bochenski, J. Warminski, W. Jarzyna, P. Filipek, M. Augustyniak. PPF versus saturation control for a strongly nonlinear beam structure.	262
8.	I.D. Breslavsky, K.V. Avramov. Nonlinear oscillations of turbomachinery blades.	266
9.	D.V. Breslavsky, O.K. Morachkovsky, N.V. Shyriaieva. Nonlinear vibrations and long-term strength of turbine blades.	272
10.	D.V. Breslavsky, I. Naumov, A. Onyshchenko. Numerical and experimental investigations of fracture in thin-walled structures at impact loading.	278

11.	V. Burlayenko, T. Sadowski. Numerical modal analysis of sandwich plates partially damaged due to impacts.	284
12.	V.Z. Gristchak, V.V. Lysenko. A hybrid asymptotic WKB-Galerkin method with application to the correlation analysis of stochastic behavior of non-linear systems with time-depended parameters.	290
13.	V.I. Gulyayev, O.V. Glushakova. The Poincare – Andronov – Hopf bifurcations in the torsion wave models of superdeep drill columns.	296
14.	K.R. (Stevanović) Hedrih. Stochastic stability of the deformable forms and vibration modes of a parametrically excited sandwich double hereditary beam system.	302
15.	K.R. (Stevanović) Hedrih, J. Simonović. Resonant jumps in multi-frequency regimes of mylti-circular plate system non-linear dynamics.	314
16.	S.N. Hudoliy, E.I. Borshch. Stability of whirl vibrations of drill string bottom assembly.	320
17.	R.E. Kochurov, K.V. Avramov. Nonlinear parametric vibrations of cylindrical shells.	326
18.	T.S. Krasnopolskaya, V.N. Il'chenko, V.V. Meleshko. Transport and mixing across Gulf Stream.	332
19.	L.V. Kurpa. Geometrically non-linear vibration and meshless discretization of the composite laminated shallow shells with complex shape.	338
20.	L.V. Kurpa, N.A. Budnikov. Multi-modal geometrical non-linear free vibrations of composite laminated plates with the complex shape.	344
21.	O.O. Larin, O.S. Stepchenko. Investigation of forced vibrations of turbine blades in consideration of rolling contact in the detachable shroud.	349
22.	M. Legrand, C. Pierre. Wear of abradable coatings. Towards multi-physics analyses for the design of turbomachines.	352
23.	A. Manevich. Dynamics of a Timoshenko beam on an elastic foundation.	358
24.	M.V. Marchuk, V.S. Pakosh. Geometrically nonlinear transversal vibrations of pliable to shear and compression plates.	364
25.	O. Mazur, A. Linnik, V. Tkachenko. Nonlinear analyses of the laminated plates of the symmetric structure subjected to static in the plane forces.	369
26.	Sh.A. Nazirov, N.G. Eshkaraeva. Mathematical modeling of deformation processes of the flexible viscoelastic plates with complex form.	375
27.	A.A. Osetrov. Application of the R-functions theory and spline-approximation to finding eigen functions as basic ones for meshless discretization of the laminated shallow shells.	377
28.	A.N. Pasechnik, V.A. Pasechnik, N.N. Novotna. Research of natural oscillations of a plate with mixed conditions of contour fastening.	378
29.	F. Pellicano. Dynamic instabilities of a seismically excited shell with shaker-shell interaction modeling.	384
30.	E. Petrov. Analysis of resonance nonlinear vibrations for high-fidelity models of structures with contact interfaces.	390
31.	Yu.V. Romashov. Equation of motion with implicit functions of phase coordinates velocities and its applications for engineering constructions rupture life evaluation.	392
32.	S.Yu. Sayenko, O.K. Morachkovsky, D.V. Lavinsky, V.N. Sobol, Yu.M. Andreev. Modeling of impact deformation processes of the ceramic container for radioactive waste storage.	398
33.	T.V. Shmatko. Investigation of dynamical instability of vibration modes for laminated plates and shallow shells.	403
34.	V.M. Spector, T.S. Krasnopolskaya. Surface waves in a fluid annulus with a vibrating inner cylinder.	409

35.	M.J. Temis, A.M. Egorov. Influence of gas turbine parameters changes to nonlinear vibrations of rotor-bearings system.	415
36.	J.M. Temis, A.V. Selivanov. Aeroelastic self-oscillations of plane channel wall.	421
37.	G.N. Timchenko, I.O. Morachkovska, N.A. Budnikov. Research of the nonlinear free vibration of the fully clamped composite laminated plates of an arbitrary planform.	427
38.	Yu. Turbal. The trajectories of self-reinforcing solitary wave in the gas disc of galaxies.	431
39.	K.A. Volosov, S.O. Sinitsyn, A.K. Volosova, E.K. Vdovina. Stochastic systems under periodic and white noise external excitations, and the alternative classification for the PDE solutions.	437
40.	A.V. Yelagin. Analysis of nonlinear anharmonic perturbations for axisymmetric longitudinal-shear waves in a cylindrical waveguide.	443

MINI-SYMPOSIUM

«CREEP AND PLASTICITY AT CYCLIC LOADING»

1.	H. Altenbach, S. Kozhar, K. Naumenko. Modeling creep ratcheting of an aluminum-silicon eutectic alloy.	449
2.	M.V. Borodii, M.P. Adamchuk. Ratcheting simulation of structural steel under low-cycle asymmetric loading.	455
3.	D.V. Breslavsky, A. Chuprynin, O. Tatarinova. Creep-damage behaviour of thin shells subjected to cyclic loading.	461
4.	D.V. Breslavsky, Yu. Korytko, O.K. Morachkovsky. High temperature creep and damage accumulation in cyclically loaded axisymmetrical bodies of revolution.	467
5.	Yu.A. Chernyakov, A.S. Polishchuk. On accounting for deformation by twinning in the theory of microstrains.	473
6.	S. Gladkov, B. Svendsen. Towards coupled finite element modeling of grain growth with plasticity.	478
7.	Z.L. Kowalewski, S. Mackiewicz, J. Szelażek, T. Szymczak, B. Augustyniak. An influence of long-term exploitation on material behaviour under constant and monotonically increasing loading.	481
8.	O.K. Morachkovsky, V.N. Sobol. Problem statement of dynamic creep for isotropic and orthotropic bodies.	487
9.	K.V. Spiliopoulos, K.D. Panagiotou. A direct method for the cyclic elastoplastic analysis of simple structures.	492
10.	A. Tkachuk. A contact-stabilized Newmark method for coupled dynamical thermo-elastic problem.	497
11.	M. Wolff, M. Böhm. Two-mechanism models and modelling of creep.	503
12.	P. Yasniy, V. Hlado, S. Fedak, I. Shulhan. Numerical simulation of crack tip opening at static and dynamic creep.	509

	ALPHABETICAL INDEX	516
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RESPONSE-OPTIMAL DECELERATION OF THE ROTATION OF A SYMMETRIC FREE RIGID BODY IN A RESISTIVE MEDIUM

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ABSTRACT

The problem of time-optimal deceleration of rotation of a free rigid body is studied. It is assumed that the body contains a moving mass connected to the body by an elastic coupling with square-law friction. Low deceleration torque of viscous friction forces also acts on the rigid body. It is assumed that the body is dynamically symmetric. The optimal control law for deceleration of rotation of the rigid body in the form of synthesis, the operation time, and the phase trajectories are determined.

INTRODUCTION

Analysis of passive motion of a rigid body with a cavity filled with viscous liquid, motion of a rigid body with a moving mass connected to the body by an elastic coupling with viscous or square-law friction and motion in a resistive medium is fulfilled in [1-8]. The problem of control of rotation of “quasi-rigid” bodies via concentrated torques of forces important for application was insufficiently studied. A class of systems resulting in smooth control actions and allowing one to apply methods of singular perturbations without accumulation of “boundary-layer”-type errors was separated [2, 9-13].

The problem of time-optimal deceleration of rotation of a dynamically symmetric body connected at a point on the axes of symmetry with a mass concerning the small linear sizes by an elastic coupling with square-law friction dissipation is studied. Furthermore, low decelerating torque of a resisting medium acts on the rigid body. Rotation is controlled by the torque of forces with the bounded absolute value. The considered model continues those studied performed earlier in [2, 9-13].

1. STATEMENT OF THE PROBLEM

Based on approach [3, 13] the equations of controlled rotations in projections onto the axes of the coordinate system attached to the fixed rigid body (Euler equations) can be represented in the form [3, 5, 6, 11, 13]

$$\begin{aligned}
 A\dot{p} + (C - A)qr &= M_p + FG^2qr + Spr^6\omega_{\perp} - \chi Ap \\
 A\dot{q} + (A - C)pr &= M_q - FG^2pr + Sqr^6\omega_{\perp} - \chi Aq \\
 C\dot{r} &= M_r - AC^{-1}Sr^5\omega_{\perp}^3 - \chi Cr
 \end{aligned} \tag{1}$$

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