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5th International Congress of the Serbian Society of Mechanics: Review

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This paper presents the most important information about the 5th Congress of the Serbian Society of Mechanics which was held in Aranđelovac on 15- 17 June 2015. The Congress was organized by the Serbian Society of Mechanics. Brief summaries of the plenary lectures and the most interesting papers presented at the Congress are shown as well.

Key words: **mechanics, theoretical mehanics, applied mechanics, kinematics, dynamics, robotics, theory of control, biomechanics, international scientific conference, Serbia.**

Introduction

THE 5th International Congress of the Serbian Society of Mechanics was held from 15th to 17th June 2015, in Arandjelovac, Serbia. The International Congress of the Serbian Society of Mechanics is organized every two years, with the aim of the overall and multidisciplinary review of current conditions and further development trends in the area of theoretical and applied mechanics. This traditional meeting of scientists and engineers, researchers, experts in the field of theoretical and applied mechanics and other related areas was organized by the Serbian Society of Mechanics (SSM) and under the patronage of the Serbian Academy of Sciences and Arts – Branch in Novi Sad and the Faculty of Technical Sciences Novi Sad. Also, the 5th Congress was sponsored by the Ministry of Education, Science and Technological Development of the Republic of Serbia as well as by the Serbian Chamber of Engineers.

The Serbian Society of Mechanics is a voluntary, non-governmental, non-profit, professional scientific organization with a long tradition, (see http://www.ssm.org.rs/).

The logo of the Serbian Society of Mechanics

The objectives of this 5th Congress was to review and discuss some of the latest trends in various fields of theoretical and applied mechanics. By presenting the original high level work and bringing together the experts and young researchers, it aims to promote the exchange of ideas in the topics of mutual interests, to establish links between scientific communities with the complementary activities and to encourage them for collaboration in times to come.

During three days, many high-quality and original papers from current research projects were presented, as well as papers on research already applied in practice or that referring to forecasting and further developments in theoretical and applied mechanics. At the 5th Congress of SSM - 2015, 95 papers were presented with more than 240 authors and co-authors. All papers were reviewed and presented in the following 6 thematic sections:

- General Mechanics,
- Fluid Mechanics,
- Mechanics of Solid Bodies,
- Biomechanics,
- Control and Robotics,
- Interdisciplinary Areas.

In three days of work during the Congress, 20 sessions were held in four halls.

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Also the Minisymposia on Nonlinear Dynamics was organized. In addition, among them, 6 invited plenary lectures were held by the authors from France, Greece, Portugal, Serbia and the United Kingdom. The full versions of all these contributions were recorded on the attached electronic storage device. The Congress was officially opened and the participants were welcomed at the Crystall Pallace Hall, Hotel Izvor, by Dragan T. Spasić, President of the Serbian Society of Mechanics and the Congress Co-chair of the 5th Congress of SDM, Full Professor at the Faculty of Technical Sciences, University of Novi Sad, Novi Sad.

The opening of the 5th Congress

The first plenary lecture was held by Dr. Dragoslav Šumarac, Faculty of Civil Engineering, University of Belgrade, Serbia.

Cyclic plasticity of structures

This lecture presents the problem of the cyclic plasticity of structures. Various problems of civil, mechanical and aeronautical structures are examined under the alternating axial and bending loading. The past work of the author and his collaborators is outlined and the problem is extended to the real truss structures and bending of beams. In addition, the damage due to microcracks appearance caused by the fatigue is elaborated. In the present paper the model of elasto-plastic behaviuor for the quasy static cyclic loading is explained. Special attention is made to hysteretic behavior and mathematical models applied for their description where an overview of application of the Preisach model of hysteresis to cyclic plasticity and damage of structure is presented. Cyclic plasticity in the uniaxial case is extended to bending of beams under alternating loading in a plastic range. Finally, the model is applied to damage analysis of material due to fatigue microcrack appearance in a plastic range. The procedure is verified on several examples of truss structures under the alternating loading. From all considerations explained in the paper it can be concluded that the Preisach model possesses a numerous advantages compared to already existing in the literature and implemented in commercial programs.

The first plenary lecture was held by Dr. Dragoslav Šumarac, Faculty of Civil Engineering, University of Belgrade,Serbia

The second plenary lecture was given by Dr. George D. Manolis, Department of Civil Engineering, Aristotel University, Thessaloniki, Greece.

Elastic wawe-fields in inhomogeneous media: boundary integral equation (BIE) solution

This lecture presented the boundary integral equation (BIE) based methodologies for the numerical modeling of elastic wave motion in naturally occurring media as well as in man-made materials (Fig.1). The main reason for using BIE is a large category of problems which involves continua with a small surface to the volume ratio. Given that under most circumstances, BIE requires a surface discretization only, substantial savings can be realized in terms of the size of the mesh as compared to domain-type numerical methods such as the finite element method (FEM) and the finite difference method (FDM). The emphasis here is on a wave motion in geological media, but information is furnished for the scientific fields such as material science. Furthermore, some work is devoted to hybrid methods, where one constituent is the BIE. These have become quite popular in recent years because they seem to combine the best features of surface-only discretization techniques with those of domain-type approaches. The result is a more rounded approach to the subject of elastic wave motion, which is the underlying foundation of all problems that have to do with time-dependent phenomena in solids. Most of the material presented herein is drawn from a recent state-of-the-art article:

- G.D. Manolis and P.S. Dineva, Elastic Waves in Continuous and Discontinuous Geological Media by Boundary Integral Equation Methods: A Review, *Soil Dynamics and Earthquake Engineering*, Vol. 70, pp. 11-29, 2015.

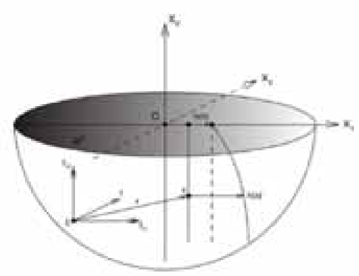

Figure 1. The elastic half-value as the basic constituent of BIE formulations

The second plenary lecture was given by Dr. George D. Manolis Department of Civil Engineering, Aristotle University, Thessaloniki,Greece.

The third plenary lecture was given by Dr. Sondipon Adhikari,College of Engineering, Swansea University, Swansea, UK. Professor Adhikari is the Chair of the Aerospace Engineering in the College of Engineering of the

Swansea University (from April 2007). In 2010 he received the Wolfson Research Merit Award from the Royal Society (UK academy of sciences).

Computational methods for nanoscale bio-sensors

Technology behind nano-scale mass sensor for sensing biological object has been growing rapidly. This lecture outlines a simple computational approach by which, using the frequency-shift of the fundamental vibration mode, the mass on an attached biological object can be predicted. It has developed a new nonlocal frequency sensor equations utilizing energy principles. Two physically realistic configurations of the added mass, namely, point mass and distributed mass (Fig.2) are considered. The exact closed-form expressions relating the frequency-shift and the added mass have been derived for both the cases. The proposed nonlocal sensor-equation is general in nature and depends on three non-dimensional calibrations constants namely, the stiffness calibration constant, the mass calibration constant and the nonlocal calibration constant. Explicit analytical expressions of these calibration constants are derived. An example of a single wall carbon nanotube with the attached multiple strands of deoxythimidine is considered to illustrate the analytical results. Molecular mechanics simulation is used to validate the new nonlocal sensor equations. The optimal values of the nonlocal parameter are obtained from the molecular mechanics simulation results. The nonlocal approach generally predicts the frequency shift accurately compared to the local approach. Numerical results show the importance of considering the distributed nature of the added mass while using the nonlocal theory.

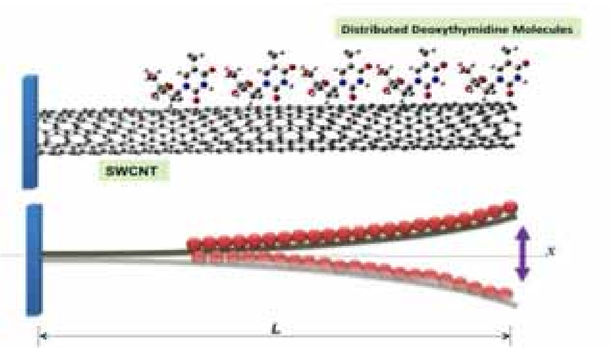

Figure 2. Idealization of a single-walled carbon nanotube (CNT) and several strands of deoxythymidine molecules as a nonlocal elastic continuum beam with the distributed mass.

The third plenary lecture was given by Dr. Sondipon Adhikari College of Engineering, Swansea University, Swansea, UK

The fourth plenary lecture was given by Dr. J. Tenreiro Machado, Institute of Engineering, Polytechnic of Porto, Dept. of Electrical Engineering, Porto, Portugal.

Fractional calculus: fundamentals and applications

The generalization of the concept of derivative $D^{\alpha} f(x)$ to non-integer values of α goes back to the beginning of the theory of differential calculus. Gottfried Leibniz invented that idea in 1695 and exchanged correspondence with Guillaume l'Hôpital about it.The development of the theory of Fractional Calculus (FC) is due to the contributions of many mathematicians such as Euler, Liouville, Riemann and Letnikov. The concept motivated mathematicians, physicists and engineers to develop the concept of FC both in theoretical aspects and practical implementations. The most used definitions of a fractional derivative of order α are, respectively, the Riemann-Liouville (RL), Grünwald-Letnikov (GL) and Caputo (C) formulations.These operators capture the history of all past events, in opposition to integer derivatives that are ''local'' operators. This means that fractional order systems have a memory of the dynamical evolution. This behaviour has been recognized in several natural and man made phenomena and their modelling becomes much simpler using the tools of FC, while the counterpart of building integer order models leads often to complicated expressions. On the other side, the function $E_{\alpha}(t)$ (known in literature as *Mittag-Leffler function*) was defined and studied by Mittag-Leffler in the year 1903 and it is a direct generalization of the exponential series. The ML function forms a bridge between the exponential and the power laws. The first occurs in the phenomena governed by the integer order and the second in the fractional order dynamics. A popular application of FC is in the area of control and corresponds to the generalization of the Proportional, Integral and Derivative (*PID*) algorithm, namely to the fractional *PID*. In the fields of physics and engineering, FC is presently associated with the modelling of electro-chemical reactions, irreversibility and electromagnetism.

The fourth plenary lecture was given by Dr. J. Tenreiro Machado, Institute of Engineering, Polytechnic of Porto, Dept. of Electrical Engineering, Porto, Portugal.

The fifth plenary lecture was given by Dr N. Challamel, Université de Bretagne Sud, LIMATB, Centre de recherche, Lorient, France.

Elastic and elastoplastic lattice foundations of nonlocal beam mechanics (N. Challamel and V. Picandet)

Nonlocal structural mechanics is an efficient engineering theory that may be able to model elastic and inelastic lattice elements, (the same kind of results may be obtained for the damage lattice systems – see *Challamel N., Picandet V. and Pijaudier-Cabot G., From discrete to nonlocal Continuum Damage Mechanics: Analysis of a lattice system in bending using a continualization approach, Int. J. Damage Mech., in Press,* 2015.)

The source of discreteness in mechanics or physics may come from the inherent nature of the matter which is composed of a discrete (or a finite) number of local repetitive cells. The present analysis is focused on the microstructured (or lattice) beam problems investigated within nonlocal mechanics. Particularly, the elastic beam lattice and the elastoplastic lattice are considered. Hencky's model, composed of *n* rigid links connected by the concentrated elastic springs of stiffness $C=EI/a$ can be considered as a lattice beam model. In case of the elastoplastic lattice, the elastoplastic constitutive law can be introduced in each elastoplastic rotational spring. A piecewise linear hardening plasticity loading function is considered in each elastoplastic spring. Also, authors showed the excellent agreement between the elastoplastic lattice model and the nonlocal elastoplastic continuum i.e. in comparison between the response of the elastoplastic hardening lattice system with the nonlocal continuous one.

The fifth plenary lecture was given by Dr. N. Challamel, Université de Bretagne Sud, LIMATB, Centre de recherche, Lorient, France.

The sixth plenary lecture was given by Dr Milutin N. Nikolić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia.

Prioritized control of humanoid robot in presence of multiple contacts (Branislav A. Borovac, Milutin N. Nikolić, Faculty of Technical Sciences, University of Novi Sad)

While walking or standing, the humanoid robots often have to perform multiple tasks while maintaining constraints satisfied. Although humanoid robots are highly redundant, sometimes it could be impossible for the robot to perform all tasks and fulfill all constraints simultaneously. That gives a need for a framework which could include constraints and task and perform them in a prioritized manner i.e. the task-prioritization framework. Up to now, the control methodology, used to solve that problem, was based on the successive null-space projections where each task is performed in a null-space of all higher priority tasks. However, that approach was well-suited only for prioritization of tasks, but not constraints. As a result, several approaches appeared where constraints can be introduced, but only on the kinematic level. However, one of the most recent generalizations of this framework has showed us how dynamical constraints can be included in the framework. Torques at all the joints are calculated in such a way, so that tasks and constraints of a higher priority are fulfilled without regard to the tasks and constraints of the lower priority. Moreover, when considering the contacts and their influence on the motion of the humanoid robot, the approach taken from the grasping theory would be applied. In order for the movement to be feasible and dynamically balanced, all contact must be sustained. When contact between the robot and surroundings is point and the Columb friction exists, the contact force must lie inside the friction cone (approximated by *n*-sided friction pyramid). For the case of planar contact, the authors have introduced a notion of dynamic balance matrix, which gives the conditions for the sustainability of the surface contacts. In that way, constraints on contact forces can be included in a framework in order to ensure stability of the present contacts. Combination of the framework with the contact sustainability constraints could be employed in order to create wide variety motions such as lifting the box, walking on flat surface, etc… Some of these examples are shown in the presentation.

The sixth plenary lecture was given by Dr. Milutin N. Nikolić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia.

Also, the fourth young author competed for the "*Rastko Stojanović*'' award at the 5th International Congress of the Serbian Society of Mechanics and after the presentations, the author, dr Damir Mađarević from the Department of Mechanics, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia, is awarded with the *"Rastko Stojanović"* diploma.

He presented the paper with the title - *Appearance of the temperature overshoot within the shock structure in binary gas mixture models.*

The author modeled the mixture of gases within the framework of extended thermodynamics adopting the multi-temperature hyperbolic model. His analysis starts with the most simple case (inviscid approximation), restricted to the non-viscous and non-heat-conducting inert gases, where the diffusion is present as the only dissipative mechanism. However, the main feature of this simplified approach is the large number of numerical integrations on the basis of which we have done systematic analysis. The results reveal the existence of temperature overshoot and its non-monotonic behavior. In the study the author includes viscosity and thermal conductivity to eliminate restriction on parameters. This enables comparison with more sophisticated kinetic solutions which were computed for the hypothetic mixtures of gases. Numerical implementation of the MT model is considerably simpler than the one for Boltzmann equations for mixtures or the direct simulation Monte Carlo method. The analysis of results is carried out with a special regard to the temperature overshoot of the heavier constituent. The presence of the extra dissipation (viscosity and thermal conductivity) implicitly introduced atomic diameters of the components in the model, which are not present in an inviscid approximation. By varying the parameters it has been found that the temperature overshoot changes non-monotonically with the mass ratio of the constituents, like in the inviscid case. Also, the dependence of the shock thickness parameter, the Mach number and equilibrium concentration on the mass ratio is analyzed.

"Rastko Stojanović" diploma

Overview of the selected papers by topic areas

Also, some of the most interesting papers are presented below.

The integrability of a motion of a symmetric rigid body (V. Dragović, B. Gajić, B. Jovanović, Mathematical Institute SANU, Belgrade)

In this paper the authors present a simple proof of the completeness of the Manakov's integrals for a motion of a rigid body fixed at a point in R^n as well as for the geodesic flows on a class of homogeneous spaces $SO(n)/SO(n_1)\times SO(n_2)\times ...\times SO(n_r)$.

Brachistochronic motion of a nonlinear nonholonomic mechanical system model (R. Radulović, D. Zeković, M. Pavišić, Faculty of Mech.Eng., University of Belgrade)

The paper analyzes the brachistochronic motion of a nonlinear nonholonomic mechanical system in a horizontal plane, between two specified positions. Differential equations of a motion are created based on the general theorems of the dynamics. The formulated brachistochrone problem is solved by applying the variational calculus. The two-point boundary value problem (TPBVP) of the system of nonlinear differential equations is solved by the shooting method. Special attention is directed to the realization of thus obtained brachistochronic motion.

Vibration of cracked nanobeam under the effects of thermal and magnetic fields (D.Karličić, D.B. Jovanović, P. S. Kozić, Faculty of Mech. Eng., University of Niš), (M.Cajić, Mathematical Institute SANU, Belgrade)

A model to describe the free vibration behavior of a cracked nanobeam, embedded in an elastic medium, by considering the effects of a longitudinal magnetic field, and temperature change, was developed in this study. In order to take into account the small-scale and thermal effects, the Euler–Bernoulli beam theory based on the nonlocal elasticity constitutive relation is reformulated for a one-dimensional nano-scale system. The effect of a longitudinal magnetic field, by considering the Lorenz magnetic force, obtained from the classical Maxwell's equation, is introduced. To develop a model of cracked nanobeam, it was supposed that a nano beam consists of two segments connected by a rotational spring that is located in the position of the cracked section. The surrounding elastic medium is represented by the Winkler's type elastic foundation. Influences of nonlocal parameters, stiffness of the rotational spring, temperature change and magnetic field on the system frequencies are considered for two types of boundary conditions.

Correlation of the Magri's method of syzygies and separation variables in some examples of the systems of the Kowalevski type (K. Kukić, Faculty for Traffic and Transport Eng., University of Belgrade), (V. Dragović, Math. Institute SANU, Belgrade)

In the recent author's papers a new approach to the Kowalevski integration procedure has been suggested. That approach resulted from the possibility to generalize the Kowalevski integration procedure on a whole class of systems, the so called Kowalevski type systems. So, the authors recognized the property of discriminant separability of the Kowalevski fundamental equation as a key property for the explicit integration of such systems.

On active seismic protection combined with both passive fractional damping and dry friction (A.Okuka, D. T. Spasić, Faculty of Tech. Sciences, University of Novi Sad)

The new tendency in seismic protection favors combinations of a base sliding isolation system, passive and active devices. The sliding isolation system permits decoupling the motion of the superstructure from the ground motion and increases its resistance to structural damage. The passive devices incorporate new high performance viscoelastic materials and dry friction elements, both ensuring strict dissipation of energy. The active control force applied simultaneously has to prevent large displacements of the superstructure.

Brachistochronic motion of a variable mass nonholonomic mechanical system (B.Jeremić, R. Radulović, A. Obradović, Faculty of Mech.Eng., University of Belgrade)

This paper considers the brachistochronic planar motion of a variable mass nonholonomic mechanical system, with specified initial and final positions. The procedure for creating differential equations of a motion based on the general theorems of dynamics of a variable-mass mechanical system is presented. The formulated brachistochrone problem, along with the adequately chosen quantities of state, is solved as a task of the optimal control by applying the Pontryagin's maximum principle. Numerical procedure for solving the TPBVP is based on the shooting method. Afterwards, the reactions of nonholonomic constraints, as well as the control forces, are determined to realize the brachistochronic motion. The analysis of the brachistochronic motion at different values of the initial position of the variable mass point is performed.

Oscillations of adjacent structures during an earthquake (M.Žigić, N.Grahovac, Faculty of Tech. Sciences, University of Novi Sad)

The authors studied the seismic response of two adjacent structures connected with the friction damper. Each of them consists of a viscoelastic rod and a rigid block, which can slide without a friction along the moving base. A simplified earthquake model is used for modeling the horizontal ground motion.Energy dissipation is taken by the presence of a friction damper, which is modeled by a setvalued Coulomb friction law. Deformation of viscoelastic rods during the relative motion of the blocks represents another way of energy dissipation. Constitutive equation of a viscoelastic body is described by a fractional Zener model, which includes fractional derivatives of stress and strain. Dynamical behaviour of the problem is governed by a pair of coupled multi-valued differential equations where the posed Cauchy problem is solved numerically by the use of the Atanackovic-Stankovic expansion formula. The behaviour of the system is analyzed for different values of the system parameters.

Fluid Mechanics

Phase-field models for capillary flows (M. Dehsara, S.Dj. Mesarović, Washington State University, USA), (H. Fu, D.P. Sekulić, University of Kentucky, USA),(M.Krivilev, Udmurt State University, Izhevsk, Russia)

Kinetics of liquid spreading over a substrate is of a fundamental importance for the applications of a number of capillary driven phenomena in the technological processes, e.g. bonding by soldering, brazing, and/or transient liquid phase bonding. Non-reactive wetting process is controlled by the competition between the triple line mobility and fluid viscosity. The standard sharp interface model combined with the Navier-Stokes equations and no-slip boundary condition at the solid–fluid interface, results in unphysical singularities. Moreover, molecular dynamics studies indicate that the motion of the triple line proceeds by uncorrelated movement of the fluid atoms on the solid surface, i.e. diffusion. Diffuse interface (phase-field) models are the natural framework for modeling such physical phenomena, whereby the triple line movement is described in terms of a local surface diffusion of the fluid. Moreover, it is the only computational model that can describe topological changes associated with the capillary flows (breaking up and coalescence of fluid domain).

Moment closure hierarchies for rarefied gases (S. Simić, Faculty of Tech. Sciences, University of Novi Sad), (M. Pavić-Čolić, Faculty of Sciences, University of Novi Sad)

The paper proposes an approximate closure procedure for the hierarchies of macroscopic equations for rarefied gases, derived as moment equations from the Boltzmann equation in a kinetic theory of gases. The procedure is based upon application of the maximum entropy principle. If the exact minimizer is exploited, moments of the distribution function may diverge, unless the restriction on the structure of the moments is introduced. Moreover, a perturbative approach is proposed by restricting the set of the admissible functions in the variational problem. This leads to an approximate minimizer, but the procedure can be applied to an arbitrary choice of the moments.

Hartmann–couette flow and heat transfer in channel with porous walls (Ž. M. Stamenković, J. D. Nikodijević, M. M. Kocić, Faculty of Mech. Eng., University of Niš),(M. D. Nikodijević, Faculty of Occupational Safety, University of Niš)

Flow of a viscous incompressible electrically conducting fluid between two infinite horizontal parallel porous plates has been considered in the paper. The upper plate moves with the constant velocity in a positive longitudinal direction, while the lower plate is stationary. The upper and lower plate have been kept at the two constant different temperatures and the plates are electrically insulated. The applied magnetic field is perpendicular to the plates, the channel plates are insulated and trough the plate's perpendicular to the surface the fluid of the same physical characteristics as the fluid in the basic flow has been injected or ejected. Effects of the magnetic field and suction/injection on the heat and mass transfer have been studied where an exact solution of the governing equation has been obtained in a closed form. The influences of each of the governing parameters on velocity, temperature, flow rate and shear stress are discussed with the aid of graphs.

Rayleigh-Benard convection secondary instability in presence of temperature perturbations on the lower plate, (M M. Jovanović, B. D. Nikolić, S. Milanović, Faculty of Mech. Eng., University of Niš)

In this paper the authors analyze the stability of the Rayleigh-Benard convection by temperature perturbations on the lower plate.They have carried out the direct numerical simulation of viscous fluid between paralel plates where the upper one is cooled and the lower one is heated. There is a slight inclination of the plates with respect to the horizontal plane in a counter-clockwise direction with the angle $\gamma = \pi / 360$. When the critical Rayleigh number is achieved the Rayleigh-Benardsteady convective cells set on. The authors investigate numerically the amplitude of the perturbation on the lower plates that cause this flow pattern to become instable and unsteady. They have carried on a series of simulation depending on the shape and amplitude that caused this instability and unsteadiness of the viscous fluid flow.

Drag-coefficient behavior of the bio-inspired high speed train designs (S. Linić, Institute Goša, Belgrade), (B. Rašuo, Faculty of Mech.Eng., University of Belgrade), (M.Kozić, Military Technical Institute, Belgrade), (V.Lučanin, A. Bengin, Faculty of Mech.Eng., University of Belgrade)

During the last decade a need for the higher travelling velocities signified, in a problem foreground of the heavy vehicle aerodynamics, the contradictory requirements of the energy saving, drag reduction, and noise pollution.This unique research presented a method of creating and analysis of a bionic high-speed train in a plain flow, as a representative of a flow in the longitudinal cross section of the Bionic design of high-speed train (BHST). With the aim to find a simple and low time consuming method for prototype design, from a number of animal species, five natural designs were selected and applied-as-are. Analysis of the pressure and drag coefficients defined directions for further work, but also highlighted the needs. The obtained results gave the advantage to BHST with the sharp and elongated nose as the kingfisher- and barracuda-like being, placed as low as possible to the ground and continued with the characteristic curved nose surface. Those designs showed the most satisfied pressure distributions in a presented configuration, but expected from them more after further adjustments.

EMHD flow and heat transfer in channel with porous walls, (M. M. Kocić, Ž. M. Stamenković, J. D. Nikodijević, J. B. Bogdanović-Jovanović, Faculty of Mech. Eng., University of Niš), (M.D.Nikodijević, Faculty of Occupational Safety, University of Niš)

The electromagnetohydrodynamic (EMHD) flow and heat transfer in a horizontal channel with isothermal walls have been investigated in this paper. Fluid is electrically conducting, while the channel plates are insulated. A uniform magnetic field is applied in the direction making an arbitrary angle to the vertical line, while electric field is perpendicular to the flow. Through the plates perpendicular to the surface the fluid of the same physical characteristics as the fluid in the basic flow has been injected or ejected. The general equations that describe the discussed problem under the adopted assumptions are reduced to the ordinary differential equations and closed form solutions are obtained. The analytical results for various values of the magnetic field inclination angle, suction Reynolds number, load factor and Reynolds magnetic number have been presented graphically to show their effect on the flow and heat transfer characteristics.

Mechanics of Solid Bodies

Damage of trusses due to cyclic plasticity (Z. Perović, D. Šumarac, Faculty of Civil Eng., University of Belgrade)

In the present paper, the cyclic plasticity of trusses is extended by taking into account the damage effects induced by the fatigue. Static structural analysis of trusses damaged under the cyclic loading in a plastic range was performed by using the Preisach model of hysteresis. Parameters for the Preisach model of cyclic plasticity are obtained from the uniaxial loading experiment. Damage, as a consequence of micro cracks appearance due to alternating loading in plastic domain, is modeled using brittle elements according to the Preisach procedure. The influence of temperature on material behavior under various cyclic loadings is analyzed through numerical analysis.

Stress integration of the Drucker-Prager material model with kinematic hardening (D. Rakić, M. Živković, Faculty of Eng., University of Kragujevac)

This paper presents a method for implicit stress integration of the Drucker-Prager material model with kinematic hardening. The stress integration of the material model is conducted by using the incremental plasticity method, while the kinematic hardening of material is defined by using the nonlinear Armstrong-Frederick hardening. This type of granular material hardening occurs as a consequence of the cyclic loading effects, such as the seismic load. For this reason, this material model is used for the earthquake analysis in the soil mechanics. Yield surface of the material model changes its position under the cyclic loads in the stress space, whereas there is no change in the size of the yield surface in a deviatoric plane. The developed algorithm of the material model has been implemented in the software package PAK.

Behavior of the frame structures in elasto-plastic domain (S. Ćorić, S. Brčić, Faculty of Civil Eng., University of Belgrade)

In this paper the phenomenon of instability of steel frames in elasto-plastic domain was investigated. Numerical analysis was performed by the finite element method. Stiffness matrices were derived using the trigonometric shape functions related to the exact solution of the differential equation of bending according to the second order theory. When the buckling of structure occurs in a plastic domain, it is necessary to replace the constant modulus of elasticity E with the tangent modulus Et. For the purposes of this numerical investigation, a part of the ALIN computer program was created in a way that this program now can be used for elastic and elasto-plastic stability analysis of the frame structures. Several characteristic numerical examples are presented in this paper. Corresponding curves between critical load, slenderness, tangent modulus and strain are obtained by a variation of columns stiffness of the analyzed frames.

On elasticity tensor of anisotropic damage mechanics (J. Jarić, D. Kuzmanović, D. Šumarac, University of Belgrade, Faculty of Civil Eng.)

The anisotropic linear damage mechanics is presented starting from the principle of a strain equivalence. In their published paper *Jarić J.P., Kuzmanović D. S. and Šumarac D. (2013) On Anisotropic Elasticity Damage Mechanics, International Journal of Damage Mechanics,* the damage tensor components are derived in terms of elastic parameters of undamaged (virgin) material in a closed form solution. Here, making the use results from the previosly published paper, the authors derived elesticity tensor as a function of damage tensor also in a closed form. The procedure is applied for several symmetries that are important for applications. As an example numerical calculation for transversely isotropic material in case of the plane stress problem is presented.

Buckling of generalized elastica supported by Cardan joints (V. B. Glavardanov, R. B. Maretić, N. M. Grahovac, M. M. Žigić, Faculty of Tech. Sciences, University of Novi Sad)

This paper deals with the problem of determining the stability boundary of a twisted and compressed rod supported by the Cardan joints. For the constitutive equations we choose ones that take into account the effect of compressibility and shear. Changing the dependent variables, the problem is reduced to the system of eight non-linear first order differential equations which are also suitable for local bifurcation analysis. These equations along with the boundary condition lead to the characteristic equation that determines stability boundary. The results show that compressibility increases the stability boundary while the shear decreases the stability boundary.

Inelasticity of metals - an application to thermal ratchetting (M. Mićunović, Faculty of Techn. Sciences, University of Kragujevac), (Lj. Kudrjavceva, Dep. of Civil Eng., State University of Novi Pazar), (M. Topalović, Faculty of Techn. Sciences, University of Kragujevac)

The paper deals with 3D thermo-viscoplastic strain of a rectangular block made of AISI 316H steel. One of its sides is loaded by a constant normal stress whereas two lateral side surfaces are acted upon by harmonically variable shear stress. Such a history induces progressive but saturated increase of the axial strain in the direction of tension stress components. The problem is treated by two constitutive models: (i) the Perzyna-Chaboches model with incorporated evolution equations for back stress and equivalent stress, (ii) the quasi rate independent (QRI) model. The QRI model based on tensor representations was also calibrated and presented in *Mićunović, M. (2009), Thermomechanics of Viscoplasticity - Fundamentals and Applications, Advances in Mechanics and Mathematics AMMA, Vol. 20, eds. R. W. Ogden & D. Gao, Springer, New York,* where plastic stretching is the third order polynomial in stress and linear in plastic strain as well as its reduced form when explicit dependence of tensor generators on a plastic strain is neglected. Comparison with experiments among these models has been done. The steady tension with harmonically changed torsion has been analyzed by FEM method. Here thermal ratchetting with two opposite sides heated was given a special attention. The FEM analysis made possible taking inhomogeneous temperature distributions into account. Some characteristic temperature-stress-strain histories are considered and shown.

Experimental and numerical analysis of perforation of thin steel plates by deformable steel penetrators (P M. Elek, S. S. Jaramaz, D.M. Micković, University of Belgrade – Faculty of Mech. Eng.), (N. Miloradović,Yugoimport-SDPR)

The paper considers the modeling of perforation of thin steel plates by cylindrical steel penetrators – fragment simulators. This problem is significant primarily for military applications.A comprehensive experimental investigation was performed and relevant data about the experiment setup and measuring equipment are reported. A numerical model developed in the Abaqus FEM based software is described in details. The Johnson-Cook thermo-viscoplastic constitutive law, as well as the Johnson-Cook damage model, is used in the model. It has been shown that simulations correctly reproduce the main mechanisms of penetration process – indentation, bulging and plugging. Computational results are compared with the experimental data in terms of the ballistic curves – diagrams that define the dependence of penetrator residual velocity on its impact velocity. Very good agreement is obtained between the results of simulation and experimental measurements.

Geometrically nonlinear vibrations of beams supported by the nonlinear elastic foundation with variable discontinuity (V. Stojanović, D. B. Jovanović, Faculty of Mech. Eng., Univerisity of Niš)

Geometrically nonlinear vibrations of a Timoshenko beam resting on a nonlinear Winkler and Pasternak elastic foundation with a variable discontinuity is investigated in this paper. A *p*-version finite element method is developed for geometrically nonlinear vibrations of a shear deformable beam resting on a nonlinear foundation with discontinuity. The elastic foundation has cubic nonlinearity with a shearing layer. In the study the *p*-element which comes from the use of explored special displacement shape functions for the damaged beams is used and applied to the model with the nonlinear foundation. The novelty of the present study lies in an easy generalization of the approach of natural frequencies, general mode shapes and maximal deflections in nonlinear steady state vibrations of the shear deformable beam for any size and location of discontinuity of the nonlinear elastic support. A new set of nonlinear partial differential equations is developed and they are solved in the time domain using the Newmark method for obtaining the amplitudes and deformed shapes of the beam in the steady state forced vibration regime. The present work consists of the comparison of the results with various stiffnesses of the nonlinear elastic support of the Winkler and Pasternak type.

Dynamic analysis of microbeam under the action of moving microparticle (M. Stamenković, Mathematical Institute SANU), (G. Janevski, P. Kozić, Faculty of Mech. Eng., Univerisity of Niš)

This paper is devoted to the problem of microbeam under the action of a moving microparticle. The equation of motion is obtained using the Hamilton's principle and modified couple stress theory (MCST), while for resolving we used the Bernoulli–Fourier method. The microbeam is simply-supported and continuously placed on the Pasternak elastic layer. A detailed parametric research is performed to study the influences of the material length scale parameter, the Poisson's ratio, the velocity of the microparticle and the modulus of the shear Pasternak's layer as well as the solution procedures on the dynamic responses of the microbeam. Analytical expressions and numerical results for deflection of the Euler–Bernoulli microbeam are derived and validated with the results founded from the other authors.

Thermal effects on vibration and stability of a multiple-nanobeam system embedded in an elastic medium (D. Karličić, Faculty of Mech. Eng., University of Niš), (M.Cajić, Mathematical Institute SANU, Belgrade), (P. Kozić, R. Pavlović, Faculty of Mech. Eng., University of Niš)

In this paper, the authors study the vibration and stability of a multiple-nanobeam system (MNBS) embedded in the Winkler's type of elastic medium subjected to the influence of temperature change and compressive axial load. The MNBS is modeled as the system which consists of *m* identical and simply supported nanobeams connected by elastic layers. Based on the Rayleigh's beam and nonlocal thermo-elasticity theory, the system of *m* coupled partial differential equations is derived and solved by using the method of separation of the variables and trigonometric method. The solutions for natural frequencies and critical buckling loads of elastic MNBS are obtained in an explicit form. The influence of temperature change, nonlocal parameter and the number of nanobeams on natural frequencies and critical buckling loads are investigated through numerical examples.

Biomechanics

A note on tissue analogues recognition (D.T. Spasić, D.V. Dankuc and N.I. Kovinčić, Faculty of Tech. Sciences, University of Novi Sad)

Consideration of the mechanical properties is essential for any material that is to be used in biomedical engineering. A good choice of material for a particular application depends on the recognition of these properties in an analysis of both similarity of biomaterials to biological ones and bio-compatibility. The characterization of the mechanical response to the typical load deformation patterns contributes to a great extent to the reliability of any simulation of the organ deformations under the physiologic loads. In this note the authors intended to show that fractional Kelvin-Zener model of viscoelastic body, as an acceptable alternative to quasilinear viscoelasticity for a description of biomaterials and tissue materials, can serve in the construction of the engineered tissue analogues.

A computational model for drug transport in tumor (M. Kojić, M.Milošević, V. Simić, Belgrade Metropolitan University – Bioeng. Research and Devel.Center BioIRCA), (Ziemys, M. Ferrari, The Methodist Hospital Research Institute, USA)

The transport of drugs within tumor is the fundamental process affecting therapeutic efficacy. Computational models which realistically simulate the drug transport within tumor can help in optimization of therapeutics parameters and better understanding of the involved physical processes. Due to the extreme complexity of phenomena governing drug transport, the development of satisfactory and feasible computational models remains a challenge. The authors have formulated an efficient multiscale-multiphysics model of the convective-diffusive transport of drugs within the tumor environment. The interactions on the molecular level between the drug and its surroundings are hierarchically included by employing the molecular dynamics (nanoscale). A numerical homogenization procedure is used to evaluate transport parameters across the tumor blood vessel walls, tissue microenvironment and nanoparticles carrying the drug (microscale). Imaging data provided the basis for the evaluation of transport parameters as well as generation of the entire tumor model. The formulated model offers an insight into drug transport within tumor for various options of therapeutics procedures.

Biomechanical model of semi-circular canal (N. D. Filipović, I. Saveljić, Z. Milošević, D. Nikolić, Faculty of Engineering, University of Kragujevac, BioIRC), (T. Exarchos, Institute of Comm. and Computer Systems, School of Elec.l and Comp. Eng. of the National Technical University of Athens)

In this study the biomechanical model of the semi-circular canals (SCC) is described. Authors investigated a model of the SCC with parametric defined dimension and fully 3D three SCC with the fluid-structure interaction from patient specific 3D reconstruction and the hot caloric test with the real patient geometry. All the models can be used for a correlation with the same experimental protocols with head moving and nystagmus eye motion. Three SCC give more details and understanding of the pathology of the specific patient and hot caloric test gives more insight in this standard clinical diagnostic procedure.

Tapered box model of the cochlea: air and bone conduction (V. M. Isailović, M. M. Nikolić, N. D. Filipović, Faculty of Engineering, University of Kragujevac, BioIRC)

The most complex part of them is the inner ear, which contains cochlea. The cochlea has the role to transform outer acoustic input signal into an electrical impulse, which is further transmitted to the brain. In order to understand hearing process and hearing disorders the cochlea behavior should be investigated and resolved. In this paper the finite element mechanical model of the tapered box cochlea is presented. Excitation of the cochlea can be evoked by the air conduction, via outer ear or by bone conduction, actually by vibrations of the temporal bones, surrounding the cochlea. The finite element cochlea model can be used to simulate both – air and bone conduction and to properly simulate mechanical behavior of the cochlea. Model shows good matching with literature data (Greenwood function) regarding to the frequency map.

Multi-layer oscillatory spherical net model of mouse zona pellucida (A. N. Hedrih, Dep. for Biomedical Science, State University of Novi Pazar), (M. Lazarević, Faculty of Mech.Eng., University of Belgrade)

Zona Pellucida (ZP) is a multi-layer mesh-like 3D structure that surrounds mammalian eggs. One of its biological functions is selectivity regarding sperm penetration. Oscillatory spherical net model of mZP is suitable for explaining the initial stadium of sperm penetration. This model is a single-layer model. On a basis of the single-layered oscillatory spherical net model of mZP we proposed the improved double layer models. Due to visco-elastic properties of ZP and its importance for mechanism of sperm penetration double layered oscillatory net model of mZP has fractional order properties. Oscillatory behavior of this double-layered system is discussed.

Control and Robotics

Comparative simulation results of second-order decomposition principle based continuous and sliding mode control of motion of a 3DOF manipulator, (Miloš Živanović, Engine Devel. and Prod., Belgrade)

This paper illustrates the second-order decomposition principle control method applied to a 3DOF manipulator model. Firstly, the nominal motion of the manipulator is stabilized by a discontinuous first time derivative of the controlling force, and two phases of the motion are distinguished. Then, by applying the same algorithm, the nominal motion is stabilized by the continuous first time derivative of the controlling force obtained by smoothing the discontinuous one. Both controlling force and its time derivative are limited in both continuous and discontinuous case. To show how the limits influence the system's behavior, the simulations are done such that the limits are reached during the manipulator motion. The simulation results are presented, compared and discussed.

Comparison of various optimization criteria for actuator placement for active vibration control of smart composite beam, (N. D. Zorić, A. M. Tomović, Z. S. Mitrović, M. P. Lazarević, M. N. Pavišić, Faculty of Mech. Eng.,The University of Belgrade)

In order to improve efficiency of the active vibration control of a smart structure, the optimization of piezoelectric actuators and sensors placement has been performed. There are various optimization criteria for the optimal placement of the piezoelectric actuator. The aim of this paper is to compare control effectiveness of a smart composite cantilever beam, where optimal configurations of actuator-sensor pairs were found by using four optimization criteria (LQR based optimization, grammian matrices, performance index and fuzzy optimization strategy). The problem is formulated as a multi-input-multi-output (MIMO) model. The beam is discretized by using the finite element method (FEM). The particle swarm optimization (PSO) method is used to find the optimal configurations for each configuration.

Stabilization of cart pendulum system by using fractional order PD controller (P.D. Mandić, M. P. Lazarević, N. Djurović, Faculty of Mech. Eng., University of Belgrade,T. B. Šekara, School of Elec. Eng., University of Belgrade)

This paper deals with the stability problem of cart inverted pendulum controlled by a fractional order PD controller. Inverted pendulum is an underactuated mechanical system because it has one control input and two degrees of freedom. Detailed mathematical model of pendulum is derived using the Rodriguez method, and a fractional order PD controller is introduced in order to stabilize it. Control strategy consists of two parts, a swing up controller and stabilizing controller. Problem of asymptotic stability of closed loop system is solved using the D-decomposition approach. Stability regions in control parameters space arecalculated using this method, and tuning of the fractional order controller can be carried out.

Robust finite-time stability of uncertain discrete-time singular systems with time-delay (S.B. Stojanović, Faculty of Technology, University of Niš, D.Lj. Debeljković, Faculty of Mech. Eng., University of Belgrade)

The problem of a robust stability for uncertain discrete-time singular systems with time-delay is addressed in this paper. The uncertainty is assumed to be norm-bounded. Based on the stability conditions for the nominal system, new criteria derived, which guarantees the uncertain system to be regular, causal and robustly finite-time stable. A numerical example is presented to demonstrate the effectiveness and advantages of the theoretical results.

Interdisciplinary Areas

Partitioned approach thermo-mechanical coupling with consideration to cyclic plasticity model at large deformations

(N. M. Busarac, V. LJ. Dunić, V. R. Slavković, R. B. Slavković, Faculty of Engineering, University of Kragujevac)

In this paper the procedure for a partitioned thermo-mechanical coupling is presented. Cyclic plasticity at large deformations is analyzed. Plastic work due to inelastic large deformation under cyclic loading is used as a volumetric heat source which results in the temperature increase. Softening effect of the material properties due to the temperature change is considered. To investigate the coupled effect among temperature, stress and deformation under cyclic loading, a coupled thermo-mechanical cyclic plasticity model with nonlinear isotropic and kinematic hardening was proposed. Partitioned approach of the thermo-mechanical coupling is developed to couple finite element programs PAKS for structural and PAKT for heat transfer analysis. Finally, the proposed coupled model was verified on a numerical example.

Nonlocal vibration of fractional order viscoelastic nanobeam with attached nanoparticle (M. S. Cajić, Mathematical Institute SANU, Belgrade), (D. Z. Karličić, Faculty of Mech. Eng., University of Niš), (M. P. Lazarević, Faculty of Mech. Eng., University of Belgrade)

This paper describes a mathematical framework to examine the free damped transverse vibration of nanobeams with the attached nanoparticles by using the nonlocal theory of the Eringen and fractional calculus. Governing equation of nanobeam with arbitrary attached nanoparticle is derived by considering the viscoelastic constitutive equation involving the fractional order derivative and nonlocal Euler-Bernoulli beam theory. The solution is proposed by using the method of separation of variables. Eigenvalues and mode shapes are determined for two typical boundary conditions. The solution of fractional order differential equation in terms of a time function is found via the Laplace transform method. The time dependent behavior is examined by observing the time function for different values of fractional order parameter and different ratios of other parameters in the model.

Implicit thermo-mechanical stress integration of shape memory alloys (V. Dunić, N. Busarac, V.R. Slavković, R. B. Slavković, Faculty of Eng., University of Kragujevac)

Shape memory alloys (SMA) are very thermo-sensitive materials which find application in many industrial and engineering applications. Until now, a variety of constitutive models have been developed to simulate a specific behavior of such materials but just few of them can consider the influence of thermo-mechanical coupling on SMA behavior. Partitioned approach for coupling of structure and heat transfer program of FEM software PAK has been employed to solve such a demand. Firstly, all variables are derived with a respect to the Lagoudas theory, to depend on stress and strain effective values and martensitic volume fraction. The dissipative energy is calculated using the thermodynamic force and increment of martensitic volume fraction in an integration point. The total dissipative energy change of the whole construction is used as a convergence criterion. It has been shown that high thermo sensitivity has a great influence on SMA behavior due to the temperature change. The observation is presented by an example of cantilever beam with the moment at the free end.

Mini-symposia – Nonlinear Dynamics

Trigger of coupled one side singularities (K.R. (Stevanović) Hedrih, Mathematical Institute SANU, Belgrade, Faculty of Mech. Eng., The University of Niš)

In this paper some research results of fascinating nonlinear dynamics of a heavy material particle along rotate rough circles with the Coulomb's type friction are presented. Also, for the case that circle rotates around an axis, the differential double equations are derived and analyzed in the particular cases in the phase plane. Model of the "route circle line" real construction design and cases of the appearance of the Coulomb's type friction force is investigated. Trigger of one side singularities are indicated in the phase potraits.

Electromechanical analogy and generalized function of fractional order energy dissipation in spherical net discrete Continuum model of mouse zona pellucida (A. N. Hedrih, Dep. for Biomedical Sci., State University of Novi Pazar), (J. T. Machado, Institute of Eng. Polytechnic of Porto, Dept. of Electr. Eng., Portugal), (K.R. (Stevanović) Hedrih, Mathematical Institute SANU, Belgrade, Faculty of Mech. Eng., The University of Niš)

During the process of maturation and fertilization Zona pellucida (ZP) passes through different oscillatory states. The aim of this work is to create an electrical analog model of the fractional order spherical net model of mouse ZP (mZP) using electromechanical analogy. For that purpose the generalized Rayleigh function of fractional order energy dissipation and the extended system of the Lagrange's equations of the second kind are considered. Several theorems of eigen main chainsand energy changes are formulated.

Syncronization proof of signal traveling in the nonlinear Chains of material particles (J. Simonović, Faculty of Mech. Eng., University of Niš)

The paper presents the identical synchronization, like one of that subsystems interaction possibility, in the dynamics of the orthogonal lattice of the chained material particles. The nature of coupling elements between particles has damped, linear and non-linear elastic properties. The one or more particles in the chain are periodically forced. Depending of the coupling elements features and the positions of excitations the synchronization effect is less or more present. The multi-parameters analyses were done by presentation of a numerical simulation in the phase space of output variables of the coupled particles. The proof of signals traveling and delaying was derived from the synchronization possibilities of vicinal particles from the different positions of the external excitations.

Analysis of vibro-impact system based on oscillator moving along rough circle line under outer one-frequency force action (S.Jović, V. Raičević, I. Čamagić, Faculty of Tech. Sciences, Kosovska Mitrovica)

The paper deals with the motion analysis of vibro-impact system based on an oscillator moving along rough circle line in vertical plane, under the action of external one-frequency force. Non-ideality of the bond originates of sliding the Coloumb's type friction force with a given coefficient μ . The oscillator consists of one heavy mass particle whose forced motion is limited by one stabile angular elongation limiter. Non-impact motion of the oscillator under the action of the external one-frequency force, divided to the corresponding motion intervals, is described by a differential equation of the motion (separately for each interval) from the group of common non-homogenous second order differential equations. The differential equation of a motion can be solved in an approximate manner using Mathematica7. The combination of the analytical-numerical results for the defined parameters of the analyzed vibroimpact system is a base for the motion analysis visualization, as the first part of this analytic research.

Vectors of mass moments and vector rotators in rigid body dynamics with coupled rotations (Lj.Veljović, G. Bogdanović, D. Milosavljević, Faculty of Eng., University of Kragujevac), (A. Radaković, University of Novi Pazar)

In this paper the authors considered coupled rotor rotations around two non- intersected axes.The expression of change of the angular momentum with respect to time is used for describing the movement of a rigid body with coupled rotations. The vector method using the mass moment vectors for investigation of the rigid body coupled rotation is useful for analysis of the coupled rotation kinetic properties especially focused to the analysis of the kinetic pressures of the both shaft bearings. Appearance of the vector rotators in the components of kinetic pressures, their intensity and their directions, as well as their relative angular velocity of rotation around component directions parallel to components of the coupled rotations is very important for understanding mechanisms of the coupled rotations as well as kinetic pressures on the shaft bearings of both shafts. As an example it considered the dynamics of a rotor with one degree of freedom and coupled rotations when one component of rotation is programmed by constant velocity. A complete analysis is given using kinematical vector rotators. By using derived analytical expressions of the gyro-rotor coupled rotations and by MathCAD software tool numerous visualizations of properties of kinetic pressures to the shaft bearings are presented.

Participants of Mini-Symposia Non-Linear Dynamics at the 5th International Congress of the Serbian Society of Mechanics

Condition for appearance of Andronov-Hopf and saddle-node bifurcations in the model of neuroendorine system with five variables (S. Maćešić, A. Stanojević, Faculty of Physical Chemistry, University of Belgrade), (Lj. Kolar Anić, Ž. Čupić, Institute of Chemistry, Technology and Metallurgy, University of Belgrade)

The stability analysis using stoichiometric network analysis (SNA) was carried out on the five-dimensional model of the hypothalamic-pituitary-adrenal (HPA) axis, an neuro-endocrine system involved in maintaining homeostasis in mammalian organisms under the physiological conditions and stress. This model simulates interactions between the most important dynamic variables: cholesterol (X1), CRH (X2), ACTH (X3), cortisol (X4) and aldosterone (X5) and it is capable to exhibit ultradian oscillations characteristic for HPA axis with period between 20 and 120 minutes. In the calculating procedure, all possible reaction pathways in the steady state were firstly determined and the corresponding matrix of extreme currents was defined. Steady state stability was obtained by examination of diagonal minors of the matrix of current rates $\boldsymbol{V}(\boldsymbol{j})$. This analysis showed that considered model can simulate supercritical Andronov-Hopf and saddle node bifurcations. In their collision the saddle-loop bifurcation was obtained. Moreover, it was found that autocatalysis is an essential process for the existence of both the Andronov-Hopf and saddle node bifurcations.

Dynamics of the elliptic billiards and rolling ball impacts (K.R. (Stevanović) Hedrih)

Model of dynamics of the elliptic billiards as an abstraction of the real billiards game is presented by one or two rolling balls. Different types of impacts of a rolling ball to boundary elliptic cylindrical surface with vertical edges and collision of two billiards rolling balls are investigated. In results, different elements of geometry, kinematics and dynamics of billiards game dynamics are presented. Some comparisons between mathematical elliptic billiards and model of elliptic billiards, presented in the paper, are discussed in the light of the Poncelet theorems. A number of new theorems are defined.

As a summary of three-day work, the Congress Co-chair, prof D. Spasić was pleased to conclude that the 5th Congress of SSM fulfilled the expectations of the organizers. He expressed his gratitude to all the authors and participants from abroad, as well as from Serbia, for their contribution and efforts which made this Congress possible and successful, and invited all the participants to the next Congress of SSM (6th) that will be organized in 2017.

In conclusion, an unanimous impression of the participants was that the 5th Congress of the Serbian Society of Mechanics 2015, which successfully ended on 17th June 2015, demonstrated a high professional and scientific level.

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5. Međunarodni kongres Srpskog društva za mehaniku: prikaz

Ovaj rad prikazuje najvažnije informacije o 5. kongresu Srpskog društva za mehaniku, koji je održan u Aranđelovcu od 15. do 17. juna 2015. Kongres je organizovan od strane Srpskog društva za mehaniku. Dat je kratak prikaz najznačajnijih radova predstavljenih na ovom kongresu, a koji se bave teorijskom i primenjenom mehanikom.

Ključne reči: **mehanika, teorijska mehanika, primenjena mehanika, kinematika, dinamika, robotika, teorija upravljanja, biomehanika, međunarodni naučni skup, Srbija.**

5-ый Международный конгресс Сербского общества механики: обзор

Эта статья представляет собой наиболее важную информацию о 5-ом конгрессе Сербского общества механики, который состоялся в городе Аранджеловац с 15 по 17 июня 2015 года. Конгресс был организован Сербским обществом механики. Здесь показано краткое описание наиболее важных документов и работ, представленных на этом конгрессе, имеющих дело с теоретической и прикладной механиками.

Ключевые слова: **механика, теоретическая механика, прикладная механика, кинематика,динамика, робототехника, теория управления, биомеханика, международный научный съезд, Сербия.**

5ième Congrès international de la Société serbe pour la mécanique: compte rendu

Ce papier présente les informations les plus importantes sur le 5ième congrès de la Société serbe pour la mécanique qui a eu lieu du 15 au 17 juin à Aranđelovac. Le congrès a été organisé par la Société serbe pour la mécanique. On a donné un bref compte rendu sur les travaux les plus signifiants présentés au cours de ce congrès et qui s'occupent de la mécanique théorique ainsi que de la mécanique appliquée.

Mots clés: **mécanique, mécanique théorique, mécanique appliquée, cinématique, dynamique, robotique, théorie du contrôle, mécanique bio, congrès scientifique international, Serbie.**