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Mathematical Institute SANU, Belgrade, Department for Mechanics
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Program of Mechanics Colloquium – May 2012

Start of each lecture is at each Wednesday at 18,00 h in room 301 F at Mathematical Institute SANU, street Knez Mihailova 36/III.

Sreda (Wednesday), 9 maj (May 9) 2012 u 18 sati (18h) **Lecture No. 1189**
Prof dr **Miha Boltežar,** Professor of Mechanics at University of Ljubljana, Slovenia

Seminar
Part I: Applied research of Laboratory for dynamics of machines and structures (Ladisk)
Part II: Dynamics of moving continuum; application to moving belts

Part I. In the first part some recent experiences of Ladisk will be given from the direction of combining theoretical and applied research in the field of dynamics of machines and structures in Slovenia. Most of the research is connected with big Slovene Tier 1 suppliers for foreign OEMs.

Part II. In the second part our aim was to develop an efficient and realistic numerical model in order to predict the dynamic response of belt drives. The belt was modeled as a planar beam element based on an absolute nodal coordinate formulation. A viscoelastic material was adopted for the belt and the corresponding damping and stiffness matrices were determined. Different damping mechanisms were proposed for the damping of the longitudinal and bending deformations and several experiments were conducted in order to obtain the damping properties. The belt-pulley contact was formulated as a linear complementarity problem together with a penalty method. This made it possible for us to accurately predict the contact forces, including the stick and slip zones between the belt and the pulley. The belt-drive model was verified by comparing it with available analytical solutions. A good agreement was found. Finally, the applicability of the method was demonstrated by considering non-steady belt-drive operating conditions.

Sreda (Wednesday), 16 maj (May 16) 2012 u 18 sati (18h) **Lecture No. 1190**
Prof. dr **Stevan Maksimović,** Military Technical Institute, Belgrade. (Project ON 174001)

Initial fatigue life estimation of helicopter tail rotor blades

Abstract. Attention in this investigation is focused on defining load spectra of helicopter blade and fatigue life estimation of critical structural components. To determine loads of blades it is necessary to use powerfull computation methods. In this investigation for determination loads of blades CFD numerical simulation is used. In this work are given loads of helicopter blade HT-40 that are obtained combining analytic and numerical simulation software CFD. To determine stresses at the critical parts here finite element software MSC/NASTRAN is used. Initial Fatigue life estimations is considered for metal structural elements of rotor blade. Computation results are compared with experiments.

Key words: Helicopter tail rotor blade, Load spectrum, CFD simulation, Finite elements, Initial fatigue life estimation

References
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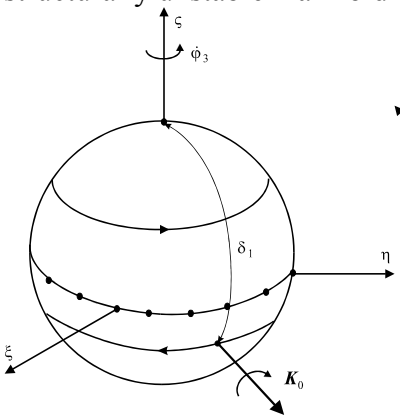
Sreda (Wednesday), 23 maj (May 23) 2012 u 18 sati (18h) **Lecture No. 1191**

Prof. dr **Pavel Krasilnikov**, MAI, Moscow, Russia

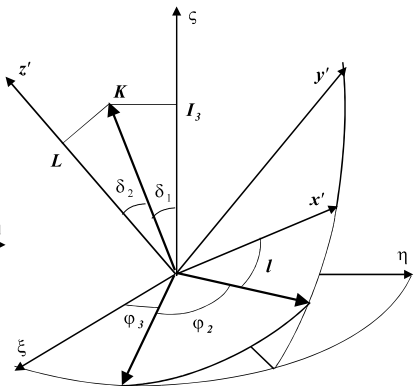
On the investigation of rotation of Uranus.

The rotations of Uranus are unusual. The spin axis of Uranus has a small tilt $7^\circ 55'$ with ecliptic plane, the planet has a return rotation. Thus, Uranus rotates, lying on one side.

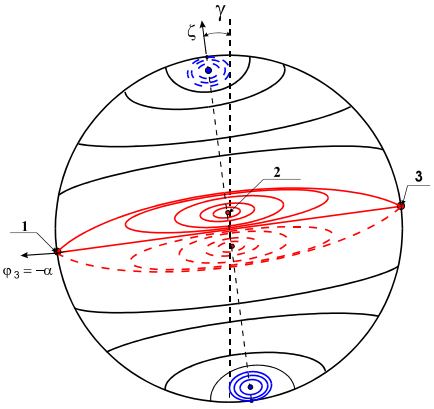
The singularity of movement of this planet is the following also. It is known that Uranus spin axis slowly rotates around a normal to the planet orbit under the influence of Sun. An axis of Uranus is inclined close to structurally unstable manifold which consists of continuum of relative equilibriums of axis (see pic. 1)



Pic.1



Pic. 2



Pic. 3

Therefore, by the attraction of Jupiter, axis can be seized into the ranges of oscillations which are located close to the plane of Uranus orbit.

The rotations of Uranus are investigated by means of averaging method provided that these rotations are described by the equations of generalized restricted three - body problem (Sun-Jupiter- Uranus). Hamiltonian's function of problem has the form

$$H=\frac{I^2-L^2}{2}\left(\frac{\sin^2\ell}{A}+\frac{\cos^2\ell}{B}\right)+\frac{L^2}{2C}+U\,,\quad U=\frac{3}{2}\omega_o^2a^3\sum_{j=1}^{2}\mu_j\frac{1}{r_j^3}\left[(B-A)(\alpha_{jy'})^2+(C-A)(\alpha_{jz'})^2\right],$$

where $\mu_1=1-\mu,\quad \mu_2=\mu,\quad \mu=m_2/(m_1+m_2)\quad r_j=\sqrt{\left(x-x_j^*\right)^2+y^2+z^2}$, $x_1^*=-\mu_2 r$, $x_2^*=\mu_1 r$, m_1 is the mass of Sun, m_2 is the mass of Jupiter, Uranus mass is the infinitesimal magnitude in comparison with mass of Jupiter and Sun, ω_0 is the mean orbital motion of Uranus; A,B,C are the central principal moments of inertia of Uranus,

$$\alpha_{jy'}=\alpha_{jy'}(l,\varphi_2,\varphi_3,L,I_2,I_3),\ \alpha_{jz'}=\alpha_{jz'}(l,\varphi_2,\varphi_3,L,I_2,I_3)$$

are the direction cosines of r_j with central principal axes of inertia of Uranus, $l,\varphi_2,\varphi_3,L,I_2,I_3$ are canonic Depri – Andoyer variables (see pic. 2)

It is supposed that orbital motions of Uranus $x=x(t),y=y(t),z=z(t)$ are described by means of quasi-periodic functions of time t.

The small parameter of problem is the ratio of an angular velocity of orbital movement of Uranus to an angular velocity of its characteristic rotation around centre of mass. It is shown that rotation of Uranus around a vector of a moment of momentum is the same as in Euler-Poinsot case. The picture of all trajectories of spin axis of Uranus on a celestial sphere for which the basic plane is Jupiter orbit plane is described. It is shown that the axis describes the lines of type of spoilt precession around a normal to Jupiter orbit plane. In a projection on the celestial sphere which has Uranus orbit plane as a basic plane, picture of trajectories turns on an angle γ, where γ is the angle between Uranus orbit plane and Jupiter orbit plane (see pic. 3)

Near to Uranus orbit plane there are oscillations as outcome of destruction of singular manifold. The width of a new oscillation range is $0^{\circ}42'04''$. It is equal to γ. The relative equilibrium of spin axis is in this zone makes an angle $0^{\circ}21'02''$ with Uranus orbit plane. This angle less than a real angle which is equal to $7^{\circ}55'$. Therefore we need a model improvement.

Sreda (Wednesday), 23 maj (May 23) 2012 u 18 sati (18h) **Lecture No. 1191**

Prof. dr **Katica R. (Stevanović) Hedrih**, Mathematical Institute SANU Belgrade, and Faulty of Mechanical Engineering University of Niš (Project ON174001)

Linearizations and approximations with applications in mechanics: Methods, assumptions, first analytic approximations and errors

Lecture start with different functions of one or more arguments and also analytical expressions and their development in series along one as well as along more arguments by using different assumptions and different methods. A series of the examples frequently present in the research in different area of sciences, in mechanics and engineering practice are presented. Development in series of the Laplace transformation of fractional order differential equation solution describing dynamics of a fractional order oscillator with one degree of freedom is presented, also

Second part of the lecture is focused to the linearizations of the nonlinear differential equations around stationary points (equilibrium positions or relative equilibrium positions of mechanical rheonomic system nonlinear dynamics) for investigation stability of the possible closed solution of corresponding nonlinear differential equation. A series of the examples describing real engineering system nonlinear dynamics are presented and analyzed. As special examples are used: nonlinear dynamics of the mechanical system with coupled rotations (oscillations around relative equilibrium positions, dynamic described by Mathieu-Hill differential equation) and system dynamics of heavy material particle motion along circle with vibrating center.

Third part of the lecture is focused to the different method for obtaining first approximations of the nonlinear differential equation solutions, in analytical forms around known analytical solutions of the corresponding simpler nonlinear differential equation or corresponding linearized differential equations. First approximations of a nonlinear differential equation obtained by different methods and around different known analytical solutions were compared for error analysis and for comparison of their limit kinetic parameter cases by multi-parametric analysis by one or more system parameter variation. As main examples are presented different first approximations of the solution of differential equations Georg Duffing type and Van der Pol type as well as nonlinear differential equations with trigger of coupled singularities and present parametric bifurcations. An complete analytical analysis of possible first approximation, in analytical form, of the solution of nonlinear differential equation describing heavy body coupled rotation around no intersecting axes, around possible stationary points will be present, with corresponding phase trajectory portraits of corresponding system dynamics described by different approximate differential equations and governing nonlinear differential equation of the system dynamics.

Keywords: Analytical approximation, starting analytical solutions, nonlinear differential equations, trigger of coupled singularities, application in mechanics, comparison, errors.

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Sreda (Wednesday), 30 maj (Nay 30) 2012 u 18 sati (18h) **Lecture No. 1192**

Professor B.Sc.M.Sc.Ph.D.**Dragica Jevtić,** Faculty of Civil Engineering, University of Belgrade, Serbia

Micro-fiber reinforced concrete and mortar – The composition, technology, properties

The paper firstly presents a brief history of the application of micro-fibers in the concrete or mortar. Furthermore, the physical and mechanical properties of the fibers (glass, steel, polypropylene, carbon and others) are given, as well as their deformation properties (σ-ε diagram, i.e. the type of behavior of fibers in cement matrix).
Special attention is given to the composition of mortar and concrete made with the use of fiber reinforcement and to the properties of such composites. The results of laboratory tests made on mortar and concrete reference mixtures (carried out in the Laboratory for materials, Institute for materials and structures, Faculty of Civil Engineering, University of Belgrade) are discussed, and compared to those mixtures made with the use of steel and polypropylene fibers. Additionally, the following properties are included: density, flexural and compressive strength, deformation properties, shrinkage, and adhesion. Types and amounts of fibers varied in the conducted experimental tests.
The results show improvement in the properties of mortars and concretes made with the use of fiber reinforcement in relation to the reference mixture, especially in terms of ductility (toughness), shear strength and tensile strength. Finally, the possibility of modeling the required properties of reinforced composites in certain cases is discussed, in terms of actual application in the construction industry and with consideration of economic factors.

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Предавања ће се одржавати средом са почетком у 18.00 часова, у сали 301 F на трећем спрату зграде Математичког института САНУ, Кнез Михаилова 36/III, (зграда преко пута главне зграде САНУ).

Позив научницима и истраживачима да пријаве сцоја предавања
Пријава потенцијалног предавача треба да садржи апстракт предавања до једне странице на српском језику ћирилицом и превод на енглески јесик, као и CV обима до две странице. Пријаву послати на адресу управника Одељења за механику у виду Word DOC на адресу: khedrih@eunet.rs

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Announcement and Invitation

Start of each lecture is at each Wednesday at 18,00 h in room 301 F at Mathematical Institute SANU, street Knez Mihailova 36/III.

All scientists and researchers in area of Mechanics are invited to contribute to the Program of Mechanics Colloquium of Mathematical Institute of Serbian Academy of Sciences and Arts. One page Abstract of proposed Lecture with short CV is

necessary to submit in world doc to Head of Department of Mechanics (address: khedrih@eunet.rs), one month before first day in the next moth.

Katica R. (Stevanovic) Hedrih
Head of Department of Mechanics