MATEMATIČKI INSTITUT SANU , ODELJENJE ZA MEHANIKU
Mathematical Institute SANU, Belgrade, Department for Mechanics

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Program of Mechanics Colloquium – NOVEMBER 2011

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), 2 novembar (November 2) 2011 u 18 sati (18h) **Lecture No. 1168**
Prof. dr Đorđe Mušicki, Mathematica institute SANU Belgrade (Projectt ON 174001)
Energy like conservation low of a non-linear oscillator in the resisting medium.

Quasi (or pseudo) conservation mechanical systems are defined as nonconservative systems for which it is possible to find new Lagrangian in the form $\widetilde{L}(q^i,\dot{q}^i,t)=f(t)L(q^i,\dot{q}^i,t)$ such that it enables the transformation of the system of their Lagrangian equations into the equivalent system of Euler-Lagrangian equations with this Lagrangian. It has been demonstrated that a nonconservative system can be considered as a quasiconservative if and only if there exists at least one particular solution which results (directly or in an indirect way) from a system of differential equations with unknown function $f(t)$.
The corresponding energy relations of these systems are analyzed as well, and it was demonstrated, if certain conditions are satisfied, that there are the integrals of motion in the form of the product of an exponential factor and the sum of the generalized energy and a term in the form $\varphi(q^i,\dot{q}^i,t)$. The condition for the existence of such integrals of motion is the existence of at least one particular solution of a partial differential equation with unknown function φ.
These integrals of motion are equivalent to the corresponding so-called energy-like conservation laws, which are obtained by application of the generalized Noether's theorem, formulated by Vujanovic and Djukic (see Vujanovic and Jones: Varialional Methods in Nonconservative Phenomena).
In this report, from the energetic point of view, a non-linear oscillator in the resisting medium with linear damping was analyzed for which besides the linear harmonic and reresisting forces there is a non-linear potential force in the form $F'=-mbx^n$, acting on it this oscillator. In this case, it has been demonstrated that the equation determining the function on f(t) has the form which is independent from the nature of the potential forces, thus , the same form as if the non-linear force was absent , and one its particular solution is $f(t)=e^{2Rt}$, where 2k is the measure of the resistance of the medium. Afterwards, one particular solutions of the cited partial differential equation is an unusual form was found, which because of the nonlinear force has a term in the form of a time integral, which contains a priori unknown function $x(t)$. In this way, the corresponding energy-like conservation law was derived, which in the absence of the nonlinear force reduced to the corresponding one far the linear oscillator in the resisting medium, while if in addition the resisting force was absent, it reduced to the known energy conservation law, exposed in the cited monograph (pp.144-149), which contains a time integral of the Lagrangian, and it has been demonstrated that there are some advantages of the energy-like conservation law, which has been presented here.

Lecture by Prof. dr Dragan Milosavljevic is canceled and translated in next period.

Prof. dr Dragan Milosavljevic, Faculty of Mechanical Engineering, University of Kragujevac
Dynamical behavior of composite plates and laminates

Composite materials consist of at least two constituents one of which is matrix and another fibre usually lay up through layers mutually bonded to make multilayered composite in the forms of laminates. Fibres carry loads giving strength and matrix bonds fibres together play important role in load transfer to fibres and forms outer shape of composite.

If material is reinforced with one family of fibres it has one privileged direction making material locally transversally isotropic in relation to that direction. Fibre direction may be defined as unit vector field $\boldsymbol{a}$ which may vary from point to point. Trajectories of unit vectors $\boldsymbol{a}$ are defined as fibres in relation to which material is locally transversally isotropic. Since fibre direction depends on position here we consider coordinate free formulation of constitutive equations. For given deformation strain energy function depends on both strain $\boldsymbol{\varepsilon}$ and fibre direction $\boldsymbol{a}$. Here is given list of matrix products whose traces make proper orthogonal group basis leading to set of invariants which may be used to form general quadratic form of strain energy function. This may be used to form stress strain relations leading to elasticity tensor for material reinforced by one family of fibres.

Here is also, following Spencer, developed constitutive relation of linear elastic material reinforced by two families of fibres defined by fibre directions say $\boldsymbol{a}$ and $\boldsymbol{b}$. Similarly, as in the case of reinforcement by one family of fibres, strain energy function depends on $\boldsymbol{\varepsilon}$, $\boldsymbol{a}$ and $\boldsymbol{b}$. List of matrix product whose traces form base for proper orthogonal group will be defined. Strain energy function in the most general quadratic form of $\boldsymbol{\varepsilon}$ will be defined, leading to constitutive equation. Elasticity tensor, in that case, has 13 elastic constants which describe material with one plane of symmetry, which is locally tangential to plane containing both families if fibres.

Plates and laminates made of above described materials show some interesting dynamic properties in propagation of elastic waves, which are dispersive. Some results of dynamic behavior when material has strong anisotropy will be displayed.

Sreda (Wednesday), 9 novembar (November 9) 2011 u 18 sati (18h) Lecture No. 1169

Dr Gordana Bogdanovic, Faculty of Mechanical Engineering, University of Kragujevac

Acoustical tensor and elastic wave propagation in anisotropic materials

Mechanical behavior of anisotropic media may be seen the best through its behavior during bulk wave propagation. Bulk waves exist in infinite homogeneous bodies and propagate unbounded without disturbances caused by either boundaries or inter-layers. Such waves may be decomposed into finite plane waves propagating along arbitrary direction $\boldsymbol{n}$ in solid.

Properties of these waves are determined by dependence between propagation direction and constitutive properties of media. Three types of such waves may be distinguished in connection to three displacement vectors, which determine acoustic polarization. Three polarization vectors are mutually orthogonal, but in most cases they are neither perpendicular nor parallel to propagation direction. The most of dynamical systems are naturally nonlinear and, since it is not easy to find closed solutions of such systems, here we are going to write Reimann-Christoffel equation, leading to three non-homogeneous linear equations which determine displacement amplitudes. This equation represents propagation condition of bulk waves as set of three homogeneous linear equations. Proper values of Reimann-Christoffel equation give phase speed of propagation of plane waves, and proper vectors represent polarization vector. This equation is the most important equation of entire theory of elastic wave propagation in crystals. Since acoustic tensor is symmetric tensor of second order, proper values are real and proper vectors are mutually orthogonal. Reimann-Christoffel equation may be solved analytically only for the simplest cases of material symmetry.

For successful display of three dimensional wave surfaces numerical analysis, which contain all propagation directions, phase velocities and polarization vectors, has been performed. The most appropriate approach in this consideration is fibre reinforced material for which proper axes coincide with global coordinate system. That is always used when crystallographic axes are known in advance. Materials used in present analysisar fibre reinforced with one or two families of continuous fibres. Since fibres are much stronger than matrix anisotropic properties are very strong. Often used represent of such materials is epoxy resin carbon fibres composite whose material constants are determined with ultrasound methods.

Sreda (Wednesday), 16 novembar (November 16) 2011 u 18 sati (18h) Lecture No. 1170

Prof. dr Ivana Kovacic, Department of Mechanics, Faculty of Technical Sciences, Novi Sad

ON SOME OSCILLATORY PHENOMENA IN TWO SYSTEMS OF THE VAN DER POL TYPE

The classical van der Pol oscillator is one of archetypical oscillators, which comprises a specific damping-like mechanism that consists of a linear part proportional to the velocity and a nonlinear part proportional to the square of the displacement and to the velocity. Consequently, energy is dissipated for large displacements and supplied to the system for small displacements, which gives rise to self-excited oscillations. For small values of the constant coefficient in the corresponding damping-like force, the amplitude becomes stationary and a stable limit cycle exists. Larger values of this coefficient results in relaxation oscillations, consisting of very slow asymptotic motion followed by a sudden discontinuous amplitude jump.

The first objective of this lecture is to give an insight into dynamics of a generalized van der Pol oscillator, with arbitrary positive real-power nonlinearities in the restoring force and arbitrary non-negative real-power nonlinearities in the damping-like force. Approximate analytical expressions for the stationary amplitude of its limit cycle are derived. The limiting values of this amplitude are found for different power nonlinearities. In addition, the time for the amplitude to 'nearly' reach the limit cycle is estimated. Relaxation oscillations are also studied and the influence of the power nonlinearities on the period of these oscillations is examined. It is shown that not only can the period increase with the damping power, but it can also have a decreasing trend for some cases. The condition for this to hold is obtained.

The second objective of the lecture is to demonstrate experimentally and analyse analytically a synchronization phenomenon in the system of two or more pendulum metronomes placed on a freely moving base. The metronomes are described as van der Pol oscillators, which are coupled due to the motion of the base. This coupling yields synchronization, which is generally in-phase. However, under special conditions, various anti-phase synchronizations can also occur as well as oscillator death. It is shown that the metronome system provides a mechanical realization of the Kuramoto model, which is used to describe and explain synchronization of self-excited biological systems.

Sreda (Wednesday), 23 novembar (November 23) 2011 u 18 sati (18h) Lecture No. 1171

Dr Ivana Atanasovska, dr Dejan Momčilović, Institute – Kirilo Savić, Belgrade

NOTCH EFFECTS IN HIGH-CYCLE FATIGUE – STANDARD METHODS VS NEW METHODS

Contemporary research in applied mechanics is based on the use of new methods enabled by enormous rise in computing power and on the multidisciplinary approach. A new multidisciplinary methodology for load capacity calculation in the case of high-cycle fatigue will be presented. This methodology used Finite Element Analysis for stress and strain calculation and prediction of the crack location, and a new method for crack initiation prediction.
Few decades ago, load capacity calculations of machine parts and constructions were based on huge number of empirical formulae, tables and graphs. Constructions with requirements of high integrity, calculated by those empirical procedures, lead to over dimensioning and miscalculations. A very rich, but also in some way confusing, literature about those standard calculation procedures have appeared in the last 50 years and is still developing.
The fracture mechanics made great advances in the 1960s and 1970s with the development of the key parameters of K, J and CTOD which allowed engineers to quantify the phenomena of brittle fracture (defined as failure by crack propagation, whatever the local mechanism of material separation) and fatigue crack propagation. Thanks to these theoretical advances it became possible to predict failure loads and times, at least when the conditions for linear elastic fracture mechanics (LEFM) were met. The 1980s saw further advances, especially in our appreciation of the underlying mechanisms of crack growth at the microscopic scale. Since then, the efforts of scientist were focused to find general rule or methodology applicable to any geometry of notch or stress raiser as well as to crack initiation criteria which will enable more accurate calculations.
The new methodology in calculation of notch effects in high-cycle fatigue will be presented. The real case study research is performed.
The range of application of this new methodology may be extended to contact fatigue problems and fatigue of weldments.

Sreda (Wednesday), 30 novembar (November 30) 2011 u 18 sati (18h) Lecture No. 1172

Prof. dr Dragutin Lj. Debeljkovic, Faculty of Mechanical Engineering University of Belgrade, (Project OI174001)

The Stability of Linear Continuous Singular and Discrete Descriptor Time Delayed Systems Defined over Infinite and Finite Time Interval

CLASSES OF SYSTEMS TO BE CONSIDERED It should be noticed that in some systems we must consider their character of dynamic and static state at the same time. Singular systems are those the dynamics of which are governed by a mixture of algebraic and differential equations. The complex nature of singular systems causes many difficulties in the analytical and numerical treatment of such systems, particularly when there is a need for their control. The problem of investigation of time delay systems has been exploited over many years. Time delay is very often encountered in various technical systems, such as electric, pneumatic and hydraulic networks, chemical processes, long transmission lines, etc. The existence of pure time lag, regardless if it is present in the control or/and the state, may cause undesirable system transient response, or even instability. These systems are described by differential with time lag argument. We must emphasize that there are a lot of systems that have the phenomena of time delay and singular simultaneously, we call such systems as the singular differential systems with time delay. These systems have many special characters. STABILITY CONCEPTS A numerous significant contributions have been made in last sixty years in the area of Lyapunov stabilty for different classes of systems. But in practice one is not only interested in system stability (e.g. in sense of Lyapunov), but also in bounds of system trajectories. A system could be stable but completely useless because it possesses undesirable transient performances. Thus, it may be useful to consider the stability of such systems with respect to certain sub-sets of state-space, which are a priori defined in a given problem. Besides that, it is of particular significance to concern the behavior of dynamical systems only over a finite time interval.

CONTRIBUTIONS OF INVITED LECTURE 1. The first part of lecture is devoted to the stability of particular classes of linear continuous singular time delayed systems (LCSTDS) and linear discrete descriptor time delayed systems (LDDTDS). A number of new results concerning stability properties of this class of systems in the sense of Lyapunov will be presented. The geometric theory of consistency leads to the natural class of positive definite quadratic forms on the subspace containing all solutions. This fact makes possible the construction of Lyapunov stability theory even for the (LCSTDS) and (LDDTDS) in that sense that asymptotic stability is equivalent to the existence of symmetric, positive definite solutions to a weak form of Lyapunov continuous (discrete) algebraic matrix equation, respectively, incorporating condition which refer to time delay term. 2. The second part of this lecture is devoted to presenting quite new results in the area of Non - Lyapunov (finite time stability, practical stability, atractive practical stability, etc.) for the particular classes of (LCSTDS) and (LDDTDS). And finally all these results will be presented, discussed and compared with actual possibilities that are offered by attractive LMI approach.

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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 јesик, 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.

Катица (Стевановић) Хедрих

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