

1. Institution

1. Institution's name	Novosibirsk State Technical University
2. Faculty (department)	Flying Vehicles Department
3. Postal address E-mail Web - Homepage	20 Karl Marx Prospect, 630092, Novosibirsk, Russia RASTORGUEV@CRAFT.NSTU.RU WWW.NSTU.RU
4. Contact person/coordinator (name, phone, e-mail, position)	Gennadiy I. Rastorguev (383-2) 46-31-32 RASTORGUEV@CRAFT.NSTU.RU Dean of Flying Vehicles Department

II. Course's profile

Applied Mechanics

5. Course title	THE SPECIAL CHAPTERS OF THE MECHANICS OF A DEFORMABLE SOLID BODY
6. Course profile (please give some key words to specify the focus)	Account on durability of elements of designs. Reinforced cylindrical shells. The deformation's mechanics of curvilinear rods. Buckling in applied mechanics. Foundations of the Nonlinear Solid Mechanics. mechanical vibrations and alternative methods of vibration control.
7. ECTS points available? (Yes/No)	No
8. Class hours/week	30 class hours/week
9. Integrated Russian language course for beginners (Yes/No, hours/week)	No
10. Language of instruction	English
11. Integrated practical training/ research program (Yes/No, brief description)	Yes, practical training or research program is extra available as well as overview excursions to some plants and research institutes in Novosibirsk.
12. Integrated cultural program: excursions etc. (Yes/No, brief description)	Excursions to the Centre of Siberian Folklore and ethnography, Regional Studies Museum, Museum of Geology, Museum of Birch-bark Art; Picture Gallery; City-guide tour. Visiting of ancient Siberian cities, as Tomsk, Omsk, Barnaul and others are available (the main aim is getting acquaintance with its history, culture, architecture, economical life). Inter-cities transfer expenses are covered by students' group additionally. Meetings and discussions with Novosibirsk students, journalists and intelligentsia.
13. Number of students (min-max)	10-25 persons
14. Tuition fees (o / month / person)	800 €/month/person
15. Course's duration	The program is designed for 5 weeks. Total amount of hours are 150.

III. Accommodation

17. Accommodation conditions: student hostel (description of accommodation facilities, incl./excl. food, costs (o / month / person)	"Universitetskaya" hotel: blocks, consisting of 2-person and 3 person rooms, toilet and bathroom. Students' canteen: meals 3 times/a day. Full costs: 20 /day/person
18. Accommodation conditions: guest family (optional): Yes/No, incl./excl. food, costs (D / month / person)	No

Additional description of the course

The description of the educational program

The program consists of five blocks, each is designed on 30 hours per week. Thus, the program is designed for 5 weeks. Total amount of hours are 150.

Block 1. Stress and strain condition of reinforced cylindrical shells
(total block are 30 hours, 20 hours lectures, 10 hours - seminars).

The lecturer - doctor of technical science, associate professor Pel A.N.

Department of Strength Aircraft Constructions of Novosibirsk State Technical University

Cylindrical shells general linear theory equations.

System of notation, co-ordinates on the shell surface.

Relations for strains and curvatures of the cylindrical shells.

Physical relations of shells theory.

Combined equations of equilibrium cylindrical shells general linear theory.

Bending moment equations of a circular cylindrical shell of constant thickness.

Simplification of the equations of cylindrical shells general linear theory of constant thickness.

Equations of shells equilibrium in displacements.

Equations solving using Fourier's trigonometrical numbers on circular coordinate.

Characteristic equation and it's features.

Characteristic equation roots investigation.

Momentless equations of a circular cylindrical shell of constant thickness.

Momentless theory equations of arbitrary kind shells.

Coordinate system on the cylindrical shell surface.

Combined resolving equations momentless theory cylindrical shells.

Equations integration.

Combined resolving equations for circular reinforcement components.

Natural trihedral joint with tangent, normal line and binormal of circular component axis line. Coordinate system joint with curved beam cross-section.

Curvatures revising and reinforcement component axis strain.

Equations of equilibrium for circular reinforcement components in displacements.

The decision of stress and strain condition of reinforced cylindrical shell problem using momentless theory equations and it's connection with semimoment smooth cylindrical shells theory.

Reinforced cylindrical shell resolving equations obtained on basis of momentless cylindrical shells theory equations.

Limitary passage to the semimoment smooth cylindrical shells theory.

The decision of stress and strain condition of reinforced cylindrical shell problem using general bending moment equations.

The development of reinforced cylindrical shell simulator on basis of bending moment shells theory.

Kinematic and static conditions of shells and reinforcing components joining.

The algorithm for stress and strain condition of reinforced cylindrical shell calculation.

Block 2. The deformation's mechanics of curvilinear rods

(total block are 30 hours, 20 hours – lectures, 10 hours - seminars).

The lecturer - doctor of technical science, professor Levin V.E.

Department of Strength Aircraft Constructions of Novosibirsk State Technical University

1. Ways of representation of a curve line's geometry

1.1. Task of geometry of a site of flat curve

1.2. Variant of the description of curve

1.3. Description of orts turn. Argyris's pseudo-vector.

1.4. Method of spatial curve's approximation

1.5. Approximation of flat curve

2. Deformation of curvilinear rods

2.1. Deformation of spatial curve

2.2. Deformation of curvilinear rod

2.3. Deformation equations of a spatial rods at the large movings and turns.

2.4. Nonlinear deformation equations of a flat rod

2.5. Linear deformation equations of a spatial rods.

2.6. Linear deformation equations of a flat rods.

2.7. Integration of the nonlinear equations of spatial curvilinear rod.

3. Examples of the numerical decision of a regional task.

3.1. The fixed rod

3.2. The Arhimed spiral

3.3. A task about deformation of an bow

3.4. A compound rod with a break of an axis

4. New effects in classic task about loss of stability of the compressed rod.

- 4.1. The exact solution
- 4.2. Approximate solution
5. Finite curvilinear elements of a rod type.
 - 5.1. Element of a flat rod. Results of testing.
 - 5.2. An element spatial curvilinear rod.
6. Features of tasks of the mechanics for systems with the large number of degrees of freedom received on finite element method. Use of systems with the reduced number of degrees of freedom.

Block 3. On buckling in applied mechanics

(total block are 30 hours, 20 hours – lectures, 10 hours - seminars).

The lecturer - doctor of technical science, professor Matveev K.A.

Department of Strength Aircraft Constructions of Novosibirsk State Technical University

1. On buckling in applied mechanics. About notion "stability". Stability in applied mechanics.
2. The buckling of beams. The buckling of naturally twisted beam at compression. The buckling of the beam at compression watching power. The Optimization of form straight beams at loss of stability. Stability of gorges and pipe lines.
3. Bases correlations of theory of stability for three-dimensional problem. Three-dimensional nonlinear problem of bounce and problems of stability. The Equations in variations. principle of virtual displacements. The Energy criterion of stability.
4. On the variation methods of study to stability of anisotropic plates under is have a temperature-power influence.
 - 4.1. The problems of stability of springy orthotropic plates under is have a temperature-power influence.
 - 4.2. The variational principles of theory of stability of springy plates under is have a temperature-power influence.
 - 4.3. The buckling of endless orthotropic plates with elliptical hole under tension.

Block 4. Foundations of the Nonlinear Solid Mechanics

(total block are 30 hours, 20 hours – lectures, 10 hours - seminars).

The lecturer is doctor of The doctor of physical and mathematical sciences, professor Korobeinikov S.N.

Department of Strength Aircraft Constructions of Novosibirsk State Technical University

The course is beginning with the summary of tensor analysis foundations. Besides, students receive skills of using of operations with tensors (internal and external tensor product, covariant differentiation, tensor gradient, tensor divergence etc.), get used to tensor designations and operations with them. The author adheres to the standard practice of use of designations.

In nonlinear continuum mechanics several different measures of strains are introduced. Following R. Hill, in the lecture course the general approach to elaboration of a class of strain tensors including known cases as special ones is offered. Their theoretical equivalence is emphasized. Introduced strain tensors are objective, i.e. they are invariant under rigid body motions. The concept of Lie derivatives of tensors is introduced. In this class the subclass of objective derivatives is pointed out. The objective derivatives used in solid mechanics equations are presented.

The Cauchy and the first Piola – Kirchhoff stress tensors are introduced. With the help of mapping operation of Cauchy stress tensor from an actual configuration on reference and a number of intermediate ones a class of natural stress tensors is introduced (the term " natural stress tensor " is introduced by the author). The objective stress tensors class is pointed out. Objective derivatives of stress tensors that are useful at the formulation of constitutive relations of solid mechanics are determined. The concept of conjugate stress and strain tensors which allows to put a determined strain tensor in correspondence to chosen stress tensor is introduced. A number of pairs of conjugate stress and strain tensors used in the formulation of solid mechanics equations are given.

The motion equations formulated with respect to reference and current configurations of the deformable body are given. A number of alternative formulations of these rate equations are considered.

Constitutive relations for a number of material models of solid mechanics establishing functional connections of stress and strain tensors and/or its rates are considered: elastic material model (in the theory of large strains one distinguishes elastic, hyperelastic and hypoelastic material models); elastic-plastic material model; elastic material model that takes into account creep strains. Special attention is given to generalization of these constitutive relations from infinitesimal to the large strains.

The initial information about numerical methods of the solution of nonlinear solid mechanics problems is given. As the basic equations for spatial discretization of the motion equations that are presented in a weak form are used. The finite element method is considered as the special form of Galerkin method with basic functions having a finite carrier. For time discretization of the equations both the explicit central-difference scheme and implicit Newmark one are used. The scheme of iterative refinement of the solution by the Newton – Raphson method in the latter case is given.

The following original author's works are used in the course:

Anin B.D., Korobeinikov S.N. Allowable forms of elastic laws of deformation in constitutive relations of elasto-plasticity [in Russian]. Siberian Journal of Industrial Mathematics, 1998, vol. 1, No 1, pp. 21-34.

Korobeinikov S.N. Nonlinear Strain Analysis of Solids [in Russian] Novosibirsk: Publishing house of the Siberian Branch of Russian Academy of Science, 2000 (the book).

Korobeinikov S.N. Strictly conjugate stress and strain tensors. J. Appl. Mech. Techn. Physics, 2000, vol. 41, No 3, pp. 513-518.

Korobeinikov S.N. Conjugate nonsymmetric stress and strain tensors. Proc. of the first Russian-Korean Intern. Symp. on Applied Mechanics (RUSKO-AM-2001) / N. V. Pustovoy (Ed). Novosibirsk: Novosibirsk State Technical University, 2001, pp. 69-73.

Korobeinikov S.N. Natural stress tensors. J. Appl. Mech. Techn. Physics, 2001, vol. 42, No 6, pp. 1051-1056.
Korobeinikov S.N. Objective Lie derivatives of tensors in the continuum mechanics [in Russian]. Symmetry and differential equations. Works of 3 international conferences. Krasnoyarsk, August, 25-29, 2002, Krasnoyarsk: Institute of computing modelling of the Siberian Branch of the Russian Academy of Science, pp. 133-139.

Block 5. Advanced studies in mechanical vibrations and alternative methods of vibration control

(total block are 30 hours, 20 hours lectures, 10 hours - seminars).

The lecturer - doctor of technical science, associate professor Goverdovskiy V.N.

Department of Strength Aircraft Constructions of Novosibirsk State Technical University

1. Introduction. The vibration protection plays a key role in the creation of transport engineering. By long-term research it was proved that vibration isolation is the most effective method of vibration protection of a man and engineering. There are no ways among the well-known with allow to solve the problem technically and, simultaneously, by acceptable costs. An acceptable compromise is the creation and application of the elastic systems having a predisposition to chaotic motion. This chaotic phenomenon could in certain cases be used as a helpful feature.

The process of the creation requires solution of another compromise due to immanent properties of the elastic systems with "negative" stiffness. This compromise is solved much more slowly and in a complicated way. And this fact confirms that there are not conceptual theoretical results in investigation of similar systems as well as engineering designs to be ready for mass production.

Recent research led to a synthesis of a new type of the elastic systems. These results help to extend the concept about the helpful properties of the elastic systems with "negative" stiffness valid to control stiffness up to arbitrary small value. A solution of the control problem, by application of a system immanently predisposed to chaotic motion, is very important with respect to the progress in vibration isolation.

The elastic systems with variable "negative" stiffness are considered as the quality control means especially in the almost insuperable infra-low frequency band. These nonlinear systems are considered with have variable stiffness in magnitude as well as in sign. These systems give us an opportunity for unlimited stiffness control in vibration protecting mechanisms despite of features of their structure, elastic characteristics, and arrangement.

The theoretical and experimental methods are called attention to study concerning synthesis of a universal "mother" element for design of the elastic systems with variable "negative" stiffness and, respectively, of stiffness control mechanisms invariant to features of the transport vibration protecting controlled mechanisms. The basic concepts are formulated on the structure of the "mother" element as well as behavioral modeling of this structure under nonlinear deformation. An approach is presented to formulate a complete system of equations to solve nonlinear problems including contact one. Computation results demonstrate that a simple numerical procedure let us simulate behavior of the structure with fine accuracy and with a small number of finite elements.

Design and control characteristics predicted by the theoretical methods have been verified through experiments as well as successful application of the stiffness control mechanisms in the seat controlled suspensions for the land vehicle drivers and helicopter pilots.

Due to structural and functional invariance, these mechanisms can be transformed and applied to vibration protection of transport machine equipment, such as the cabin, engine, containers, vehicle-borne and airborne measuring instruments, microelectronics production etc.

2. The scope lecture topics (*A daily schedule*)

2.1. A few advanced studies in mechanical engineering (2 hours + seminar of 1 hour).

2.2. Foundations of the vibration theory (3 hours).

2.3. Up-to-date traditional and alternative methods of vibration control (2 hours + seminar of 1 hour).

2.4. Vibration protecting and measuring controlled systems with small and "negative" stiffness. The theoretical methods of synthesis and analysis (3 hours).

2.5. Vibration protecting and measuring controlled systems with small and "negative" stiffness.

Design methods and applications (2 hours + seminar of 1 hour).

3. Lecture and seminar subjects (*These are selected by the customer*)

3.1. Terminology. A general model of vibration motion. Vibration characteristics. Concept about equation of system. Linear and nonlinear systems.

3.2. The classification of vibratory systems.

3. Dynamics of the vibratory systems. A few simple methods of modeling the vibration motion. Energy relationships.

3.4. Dynamics of the vibratory systems. Lagrangian dynamics. The principles of dynamics. The differential equations of vibratory systems. LaGrange equations of motion.

3.5. Analysis methods of vibration motion.

3.6. Stability of motion of the vibratory systems.

3.7. Response of dynamic systems.

3.8. The behavior of linear vibratory systems.

3.9. The behavior of nonlinear vibratory systems. Methods of approximation.

3.10. Parametrically excited vibrations. General mathematical relationships. A transition to the vibrating continuum. Stabilizing effect.

3.11. Forced vibrations. General exciter functions. Gain function and phase relationships. Power and work in forced vibrations. Transfer function, frequency response.

3.12. Transient vibration processes. Statistically distributed excitations.

3.13. Chaotic vibrations and methods of detecting and measuring chaos.

3.14. Coupled vibrations. Principal vibrations and principal coordinates. Vibratory systems with two degrees of freedom.

Natural frequencies as extreme values of an energy expression. Vibratory systems with a multiple number of degrees of freedom.

3.15. Vibration measurement and analysis. General measurement requirements. Analyzing methods. Vibration measurement via transfer functions. Recording methods. The choice of optimum data for apparatus design. Filters.

3.16. Vibration simulation.

3.17. Vehicle vibrations. Transport machines' vibration standards.

3.18. STANDARDS AND TEST CODES FOR BIOLOGICAL OBJECTS. EVALUATION OF HUMAN EXPOSURE TO WHOLE-BODY VIBRATION.

3.19. Vibration protection of technical and biological objects. Formulation of the vibration protection problem. The methods of vibration protection.

3.20. In search of the compromise between desire and opportunity for vibration protection. Vibration prediction.

3.21. Structural optimization of a vibratory system.

3.22. VIBRATION ISOLATION OF MACHINES AND EQUIPMENT. EFFECTIVENESS OF VIBRATION ISOLATION.

3.23. Materials and designs having proper elasticity. The synthesis of the elastic systems. The effect of the mass of a spring.

3.24. Structures having unique elastic properties. Elastic system with alternating signs stiffness. A few initial concepts and reasoning. Some easiest examples of elastic system with "negative" stiffness.

3.25. Thin-walled elastic structures with variable "negative" stiffness. Criteria of selection and synthesis of the "mother" elastic elements.

3.26. Improving of the commercial vibration protecting mechanisms.

3.27. TYPE, NUMBER AND DIMENSIONAL SYNTHESIS OF THE VIBRATION PROTECTING MECHANISMS.

3.28. DESIGN METHODS FOR THE VIBRATION PROTECTING MECHANISMS. A POINT OF COMPROMISE BETWEEN DESIRE AND OPPORTUNITIES. AN OPTIMAL VIBRATION PROTECTING MECHANISM.

3.29. Methods of vibration control in machines and equipment. Passive control. Active control. Active control systems. Control techniques. Adaptive and mix control systems.

3.30. Materials and designs having proper dissipation. Consideration of damping effects. External, structural and internal damping. Complex stiffness. Damping characteristics of elastic materials and designs. Criteria of damping.

3.31. Per-fluorine compounds for vibration protecting mechanisms.