

**INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH
POLISH ACADEMY OF SCIENCES**



**DOCTORAL STUDY
PROGRAMME**



Warsaw 2012



The mission statement of the Institute is to conduct high quality research in areas that are the focus of world science and technology. The most important fields of the Institute's expertise include theoretical and applied mechanics, theory of coupled mechanical and physical fields, theoretical and experimental mechanics of materials and structures, computational methods in mechanics, accousto-electronics, and ultrasonic medical diagnostics. Extensive research is also conducted in several branches of fundamental science and technology, such as physics and thermodynamics of continua, fluid mechanics, laser beam interaction with metal surfaces, nano-photonics, applied mathematics, applied informatics, and bioinformatics. Together with the results of scientific research, the Institute has developed a wide range of modern technologies, a considerable number of original measurement and diagnostic equipment, both engineering and medical, and a number of innovative computer codes. These products were developed in close cooperation with industrial partners.

IPPT PAN Doctoral Study plays an important role as the third level education, utilizing the potential of highly qualified academic staff. In 1968-2012 there were more than 700 graduates of doctoral studies at IPPT PAN. Within this time the Institute has also promoted 222 habilitations.

IPPT Doctoral Study plays an important role being the third level of education provided by the highly qualified academic staff. We invite graduates with a strong motivation for scientific work, determined to sacrifice a few years to realize their ambitious research plans.

IPPT is one of the largest technical institutes of Polish Academy of Sciences and offers a wide range of research profiles in the fields of basic science, technique and technology. IPPT is a member of the Consortium Biocentre Ochota. It creates new opportunities related to the synergy of technology, experimental medicine and biology using the potential of research institutes located at the Campus Ochota.

Doctoral education at the Institute is largely based on the student's personal research project, which is complemented with courses and clearly specified knowledge requirements. Studies must be concluded in four years and the PhD degree is awarded on the submission of a thesis and completing its public defense.

Local association of PhD students helps to assimilate newcomers and to integrate with PhD students of the Biocentre Ochota.



Recruitment

- Form "Application for Admission": Please state your doctoral study programme and the topic of your doctoral thesis and if possible the name of your supervising professor.
- Diploma certificate and graduation diploma.
- Transcript: official record of mode and length of completed programme, all taken examinations including title of lectures as well as title of your written thesis, marks awarded and credit system.
- Abstract of your diploma thesis.
- Evidence proving your present status, where applicable.
- Curriculum vitae showing your education without any gaps.
- Diploma Supplement if available.



TEACHING PROGRAMME

Basic Mathematics in Engineering Science

Kazimierz Piechór, Ph.D., Dr. Habil.

Department of Mechanics and Physics of Fluids

The aim of this cycle of lectures is to recollect and, in many cases, to supplement elementary knowledge of mathematics, which the PhD students have received during their university courses or, maybe, they had not such an opportunity, depending on the type of study. In pursuance of the recommendation of the Scientific Council of the Institute, the program of the lecture is so constructed lest it is a pure recollection and supplement but it to be a surpass of the range of mathematical teaching usually realized during engineering studies.

Main topics:

1. Elements of mathematical logic. Algebra of sentences and quantifiers.
2. Sets and algebra of sets. Cartesian product of sets. Equivalence relation. Function as a relation.
3. Cardinality of sets. Countable and uncountable sets. Infinite algebra of sets.
4. Elements of topology of metric spaces. Metrics and examples. Open, closed, compact sets. Continuity of function. Properties of functions defined on open and compact sets.
5. Cauchy sequences and complete metric spaces. Banach fixed point theorem (the principle of contraction mapping).
6. Elements of linear algebra. Fields and vector spaces, examples. The basis and dimension of the space. Linear mappings, matrices. Scalar product.

The total number of lecture hours: 30, laboratory exercises: 30 hours, self-teaching: 30, direct tutoring and consultations: 5 hours.

ECTS Points: 3



Fundamentals of Tensor Calculus

Katarzyna Kowalczyk-Gajewska, Ph.D., Dr. Habil., Civ. Eng.

Department of Mechanics of Materials

The course contains fundamentals of tensor calculus necessary for the description of problems within continuum mechanics including basic notion of linear algebra, definition of a tensor product and other tensor operations, invariant decompositions of tensors of a second and fourth order, symmetry groups of tensors and tensor functions and elements of tensor analysis.

Main topics:

1. Basic notions of linear algebra (e.g.: a group, a linear space, the Euclidean space). Basis of the Euclidean space. Transformation rules.
2. Tensor product and the tensor space of an arbitrary order. Basis of the tensor space and transformation rules for tensors. Tensor operations. Tensor as a linear operator. Automorphisms of a tensor space.
3. Spectral decomposition of a second order tensor. Orthogonal invariants of tensors. The Cayley-Hamilton theorem. Polar decomposition of the second order tensor.
4. Symmetry groups of tensors and tensor functions. Invariant decomposition of the fourth order tensors. Elements of the theory of tensor function representation. Derivatives of tensor functions.
5. Derivative and integral operations for a tensor fields in an affine space. Tensor fields in curvilinear coordinate systems.

The total number of lecture hours: 30, laboratory exercises: 15 hours, self-teaching: 40, direct tutoring and consultations: 15 hours.

ECTS Points: 4



Mechanics of Continuum

Katarzyna Kowalczyk-Gajewska, Ph.D., Dr. Habil., Civ. Eng.
Department of Mechanics of Materials

The course presents basic concepts of continuum mechanics, namely description of kinematics of deformable material body within the large strain framework, the stress measures definitions, conservation laws and a short overview of classical constitutive models.

Main topics:

1. Description of motion and deformation of a body within the large strain regime (e.g.: deformation and strain measures, interpretation of their components, velocity field and a material derivative, the change of the infinitesimal volume and surface elements).
2. Stress state (e.g: Cauchy stress principle, eigen-value problem for the stress tensor, stress measures at the reference configuration).
3. Conservation laws in Continuum Mechanics (e.g.: global and local formulations in the current and reference configurations).
4. Constitutive equation (e.g.: objectivity principle, anisotropic linear elasticity and thermo-elasticity at small strains, hyper-elasticity and hypo-elasticity at finite strains, fundamentals of plasticity and visco-plasticity theory).

The total number of lecture hours: 30, laboratory exercises: 15 hours, self-teaching: 40, direct tutoring and consultations: 15 hours.

ECTS Points: 4



Microhydrodynamics

Assoc. Prof. Maria L. Ekiel-Jeżewska, Ph.D., Dr. Habil.

Department of Mechanics and Physics of Fluids

Systems of micro-objects moving in fluids are in focus of modern science, owing to numerous biomedical and industrial applications, including lab-on-chip factories. The goal of the course is to introduce theoretical foundations needed to describe dynamics of such systems.

Main topics:

1. Dynamics of micro-particles in fluids - time scales, fluid inertia, Reynolds number, reversibility of flows, examples.
2. Stokes equations, boundary conditions.
3. Grand resistance and grand mobility problems, hydrodynamic interactions in the presence of external forces, torques or ambient flows.
4. Particulate flows in a bounded geometry, Green tensors, point-particle model.
5. Multi-pole method of solving the Stokes equations, Rotne-Prager approximation.
6. Motion of rigid and flexible multi-particle systems.
7. Self-diffusion in dispersive media.
8. Examples of applications (bacteria, algae, polymers, proteins, micro and nangles).

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 60, direct tutoring and consultations: 15 hours.

ECTS Points: 4



Ultrasound in Medicine

Prof. Andrzej Nowicki, Ph.D., Dr. Habil., Electr. Eng.

Department of Ultrasound

The course contains the fundamentals of the ultrasound in medical imaging including physical nature of ultrasonic waves propagating in tissue like materials and ultrasonic sources used. Properties of isotropic media will be described. The basic parameters like impedance, energy, intensity and radiation pressure will be addressed. Next we will discuss the reflection and refraction, attenuation, absorption and scattering. Field calculation will be explained on the basis of Rayleigh-Sommerfeld diffraction equations, Rayleigh integral and impulse response will be discussed. The important part of ultrasonic imaging is related to the different transducers - linear, phase arrays and specific beam forming including synthetic apertures. Contrast agents and nonlinear acoustic based on KZK equation will be considered. The course is dedicated to the students being interested in medical imaging and bioengineering.

Main topics:

1. Introduction.
2. Physics of ultrasounds: wave equations, Helmholtz equation, solutions to the wave equation, reflections, pulse functions, attenuation, dispersion.
3. Different scanning ultrasonic pulses: bandpass signals, reflections, scattering, scattering statistical properties, speckle noise.
4. 2D imaging: Fresnel and Fraunhofer approximations, derivation of the point spread function, Huygens' principle, wave propagation - diffraction (focusing), as in optics.
5. Basic of the ultrasonic transducers: flat and focused transducers – O'Neil's formula.
6. Array systems: linear, convex and phase arrays, Anatomy of the ultrasonic beam beamforming, dynamic focusing), sampling – side lobes and grating patterns.
7. Ultrasonography scanning systems: block diagrams and signal analysis.
8. Synthetic apertures: basic theory and designs.
9. Encoded ultrasonography: resolution/penetration, linear frequency modulation – chirp, Barker codes, Golay codes, compression in time and frequency domain.
10. FPGA based novel ultrasonic systems.
11. Introduction to nonlinear ultrasonography: nonlinear wave propagation, harmonic imaging, pulse inversion imaging.
12. Contrast agents in ultrasonographic imaging.
13. Doppler blood flow measurements: continuous wave CW Doppler, pulse wave PW Doppler, blood flow spectrum analysis, color coded flow mapping, Power Doppler.

The total number of lecture hours: 30, laboratory exercises: 6 hours, self-teaching: 80, direct tutoring and consultations: 20 hours.

ECTS Points: 5



Optical waves at nano-photonic planar structures

Prof. Wojciech Nasalski, Ph.D, Dr. Habil.

Department of Theory of Continuous Media

The course is aimed at students who intend to apply methods of optics in exploring contemporary problems of nano-photonics. The first three sections provide elementary description of electromagnetics and optics of multi-layers, as well as basics of beams and wave packets. The three subsequent sections introduce fundamentals of plasmonics, meta-materials and nano-visualisation.

Main topics:

1. Electromagnetic field.
 - 1.1. Maxwell's equations.
 - 1.2. Boundary conditions.
 - 1.3. Hertz potentials.
 - 1.4. Field polarisation frames.
 - 1.5. Monochromatic plane waves.
 - 1.6. Field integral representations.
2. Layered structures.
 - 2.1. Reflection and refraction of waves.
 - 2.2. Waves in layered media.
 - 2.3. Absorption and attenuation of waves.
 - 2.4. Bragg diffraction and scattering.
 - 2.5. Waves at double periodic media.
3. Beams and wave packets.
 - 3.1. Monochromatic Hermite-Gaussian beams.
 - 3.2. Monochromatic Laguerre-Gaussian beams.
 - 3.3. Non-monochromatic wave packets.
 - 3.4. Monochromatic Bessel-Gaussian beams.
4. Plasmonic structures.
 - 4.1. Surface plasmon polaritons.
 - 4.2. Localised plasmons.
 - 4.3. Resonances of plasmonic structures.
 - 4.4. Enhanced light transmission and sensing.
5. Meta-material structures.
 - 5.1. Double-negative materials.
 - 5.2. Negative refraction.
 - 5.3. Perfect lenses and invisible objects.
 - 5.4. Anisotropic and hyperbolic meta-materials.
6. Visualisation of nano-material structures.
 - 6.1. Evanescent and leaky waves.
 - 6.2. Atomic Force Microscopy.
 - 6.3. Scanning Near-field Optical Microscopy.

The total number of lecture hours: 60 h, laboratory exercises: 8 h, self-teaching: 90 h, direct tutoring and consultations: 20 h.

ECTS Points: 6



Fundamentals of Vibration Theory for Discrete and Continuous Systems

Assoc. Prof. Tomasz Szolc, Ph.D., Dr. Habil., Mech. Eng.

Department of Intelligent Technologies

The course contains fundamentals of vibration theory for discrete and continuous systems including also wave propagation effects. This lecture is mainly dedicated to mechanical systems and structures, nevertheless, the gained knowledge can be also used for current vibrations in electrical circuits. Moreover, the primary cases of parametric, self-excited, non-linear vibrations, vibrations of rotating systems as well as fundamentals of dynamic diagnostics and vibro-isolation of technical objects will be considered.

Main topics:

1. Fundamentals of mechanical vibration theory.
2. Dynamic analysis of discrete systems.
3. Dynamic analysis of continuous and discrete-continuous (hybrid) systems.
4. Fundamentals of elastic and visco-elastic wave propagation in one - and two-dimensional media.
5. Fundamentals of parametric, self-excited, non-linear vibrations and vibrations of rotating systems.
6. From the continuous system to finite elements.
7. Introduction to dynamic diagnostics and vibro-isolation problems.

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 60, direct tutoring and consultations: 15 hours.

ECTS Points: 4



Numerical Methods in Mechanics

Prof. Czesław Bajer, Ph.D., Dr. Habil., Civ. Eng.
Department of Intelligent Technologies

The course gives the students the fundamental knowledge of discrete methods applied to time dependent problems of mathematical physics, mainly dynamics of structures.

Main topics:

1. Time integration of differential equations.
2. Structural dynamics and numerical simulation.
3. Impact engineering.
4. Space-time finite element analysis in mathematical physics.
5. Numerical aspects of large scale discrete analysis.

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 15, direct tutoring and consultations: 10 hours.

ECTS Points: 2



Contact Mechanics

Prof. Stanisław Stupkiewicz, Ph.D., Dr. Habil., Mech. Eng.

Department of Mechanics of Materials

Contact interactions are present in many engineering applications. The course presents basic concepts of modern contact mechanics and selected advanced topics.

Main topics:

1. Overview of contact phenomena.
 - rough surfaces and real contact area,
 - contact compliance,
 - friction,
 - lubrication,
 - wear,
 - contact heat transfer,
 - granular materials.
2. Constitutive modeling of contact phenomena, including micromechanical approaches.
3. Continuum contact mechanics.
 - small-strain formulations,
 - finite-deformation formulations,
 - contact problem as a constrained minimization problem,
 - coupled thermo-mechanical contact problems,
 - classical analytical solutions in the theory of elasticity and plasticity.
4. Computational methods for contact mechanics (computational contact mechanics).
 - discretization techniques in the context of the finite element method,
 - treatment of contact constraints.

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 40, direct tutoring and consultations: 10 hours.

ECTS Points: 3



Differential Equations in Natural Sciences

Bogdan Kaźmierczak, Ph.D., Dr. Habil.

Department of Mechanics and Physics of Fluids

The objective of the course is to give an introduction to the theory of both ordinary and partial differential equations with some applications in natural sciences.

Main topics:

1. Existence theorems and properties of solutions to systems of linear ordinary differential equations.
2. Systems of nonlinear ordinary differential equations.
3. Introduction to partial differential equations.
 - Existence theorems and properties of solutions to linear elliptic equations.
 - Existence theorems and properties of solutions to linear parabolic equations.
4. Nonlinear theory: fixed point methods, sub- and super-solution methods.
5. Traveling waves for systems of parabolic equations.
6. Some specific applications.

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 15, direct tutoring and consultations: 10 hours.

ECTS Points: 2



Introduction to Modelling of Multiphysics Problems

Tomasz G. Zieliński, Ph.D., Civ. Eng.
Department of Intelligent Technologies

The course is devoted to mathematical modelling of fundamental problems of physics with an emphasis put on existing or possible multi-physics couplings. It consists of a few introductory lectures concerning relevant mathematical tools and numerical methods, as well as a series of lectures devoted to single- and multi-physics problems. The course tends also to provide a practical introduction to COMSOL Multiphysics environment.

Main topics:

1. General mathematical preliminaries: Partial Differential Equations, tensor notation, integral theorems, etc.
2. Fundamentals of the Finite Element Method: the Weighted Residual Methods, the equivalence of strong and weak forms, the Ritz-Galerkin method, FEM procedure, shape functions, etc.
3. Heat transfer.
4. Elasticity and thermo-elasticity (thermo-mechanical coupling).
5. Ideal flow theory and basic aerodynamics.
6. Elementary viscous flow.
7. Waves in fluids.
8. Acoustics and vibro-acoustics (acoustic-structural coupling).
9. Piezoelectricity (electro-mechanical coupling).

The total number of lecture hours: 30, laboratory exercises: 4 hours, self-teaching: 45, direct tutoring and consultations: 15 hours.

ECTS Points: 3



Introduction via Applications to Calculations Using High Performance Computers

Eligiusz Postek, Ph.D., Civ. Eng.

Department of Computational Sciences

The course will concern the way of work, basic tools and libraries used on HPC. We will stress on the parallel programs. We will show the selected FEA (Finite Element Analysis) and MD (Molecular Dynamics) programs. The students will perform several exercises on a computing cluster in ICM and a new computing cluster in IPPT. They will write simple FEA programs supplied with parallel sparse solver. Since the course will comprise of several exercises on remote computers the participants should have Linux and/or Windows laptops with WiFi cards. In the case of Windows, the X-Cygwin should be installed.

Main topics:

1. Structure of nonlinear and linear FEA programs.
2. Elements of MPI.
3. Linear systems of equations solvers.
4. Examples of nonlinear problems and solution algorithms.
5. Domain decomposition.
6. Particle methods.

Projects and exercises: implementation of linear and nonlinear problems employing a sparse solver.

The total number of lecture hours: 30, laboratory exercises: 8 hours, self-teaching: 60, direct tutoring and consultations: 15 hours.

ECTS Points: 4



Programming, Numerics and Optimization

Łukasz Jankowski, Ph.D., Comp.-Sc. Eng.
Department of Intelligent Technologies

The students will obtain a broad picture of commonly used numerical techniques for linear systems, ordinary differential equations and (structural) optimization. They will achieve a general understanding of the internals/pitfalls of frequently used functions of mathematical/engineering software packages. As a result, they should be able to use these functions more consciously and less in a black-box manner. In their practice, the students will sooner or later encounter problems that are too large, too fine or that run too slow to be fully coded using standard mathematical software packages (Matlab, Mathematica, Scilab, etc.). The course will prepare the students for solving such problems in general-purpose programming languages.

Main topics:

1. Introducing the principles of *numerical computations* (conditioning, stability, etc.) and *selected numerical techniques* for linear systems and ordinary differential equations.
2. Providing an overview of optimization techniques and introducing selected optimization algorithms.
3. Introducing basics of optimization techniques in structural engineering, including commonly used methods of sensitivity analysis.
4. Providing a foundation for implementing some of these techniques in any programming language (C/C++ is used within the course).

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 40, direct tutoring and consultations: 15 hours.

ECTS Points: 3



Atomistic-continuum modelling of defects in crystal structures

Prof. Paweł Dłużewski, Ph.D., Dr. Habil., Mech. Eng.
Department of Computational Sciences

The course concerns the modeling of various crystal defects observed in: semiconductor structures, metals and hetero-structures. It concerns extended defects like dislocations, stacking faults, low-angle grain boundaries and the interfacial zones formed during the crystal grown on foreign substrates, e.g. during the growth of wurtzite- and copper-type structures on sapphire. The recent methods of atomistic reconstruction of crystal defects together with the analysis of HRTEM images of defects observed in the nano-scale are discussed. The multi-scale modeling from the viewpoint of the macro-continuum approach as the finite element method (FEM) is found to be, via atomistic modeling, to the computational problems connected with the modeling the optoelectronic properties by the use of the resultant electric potential shift induced by piezoelectric effect.

Main topics:

1. Tensor calculus with elements of crystallography.
2. Extraction of distortion tensor fields from HRTEM images.
3. Mathematical theory of dislocations vs. finite deformation theory.
4. The atomistic reconstruction and modeling of crystal defects.
5. The quantum walls and dots on HRTEM images.
6. FE modeling of residual stresses.
7. FE modeling of the diffusion of chemical elements and point defects in semi-conductor crystals.
8. FE modeling of piezoelectric fields in chemically inhomogeneous crystals.
 - the effect of piezoelectric shift on optoelectronic properties of quantum dots,
 - the effect of dislocations on the stress and electric field distribution.

The total number of lecture hours: 20, laboratory exercises: 20 hours, self-teaching: 60, direct tutoring and consultations: 30 hours.

ECTS Points: 5



Introduction to measurement techniques in structural mechanics

Grzegorz Mikułowski, Ph.D, Mech. Eng.

Krzysztof Sekuła, Ph.D., Mech. Eng.

Department of Intelligent Technologies

The course is devoted to fundamentals of experimental measuring techniques and data processing in structural mechanics. The course contains two educational blocks: lectures and practice course. The lectures are dedicated to elementary aspects of measuring issues suitable for structural mechanics testing. The practice course contains conducting experiments using the hydraulic machine for material testing system and experiments by means of the drop-test tower.

Main topics :

1. Techniques and equipment in experimental structural mechanics.
2. Characterization of transducers utilized in experimental structural mechanics.
3. Fundamentals of digital signal processing.

Practice course:

1. Strain measurements with resistance strain gauges and piezoelectric strain gauges. Experiments using the hydraulic material testing machine.
2. Measurements of transient mechanical quantities in dynamic test. Experiment using the drop test tower. Measurements with indirect methods.

The total number of lecture hours: 8, laboratory exercises: 8 hours, self-teaching: 15, direct tutoring and consultations: 20 hours.

ECTS Points: 2



Shape Memory Alloys

Experimental Behavior, Modeling and Engineering Applications

Andrzej Ziółkowski, Ph.D., Dr. Habil., Mech. Eng.

Department of Intelligent Technologies

The course is devoted to shape memory alloys (SMA) a class of advanced materials deriving their special functional and utility features from undergoing in the material solid-solid phase transformations. Experimental behavior of SMA materials submitted to various thermo-mechanical loadings is presented. The basic concepts of non-equilibrium thermodynamics are discussed necessary for grasping in modeling terms phenomena resulting from strong mutual coupling of thermal and mechanical fields. A thermodynamic, macroscopic constitutive model of shape memory alloy materials is presented enabling reliable characterization of SMA materials and modeling shape memory effects. Selected case studies of successful engineering applications of shape memory alloys in terms of design problems are discussed.

Main topics:

1. Overview of Shape Memory Alloys.
2. Thermo-mechanical behavior and modeling approaches to Shape Memory Alloy materials.
3. Thermodynamic modeling and characterization of shape memory alloys.
4. Application areas of shape memory alloys.

The total number of lecture hours: 30, laboratory exercises: 0 hours, self-teaching: 40, direct tutoring and consultations: 15 hours.

ECTS Points: 3



Experimental Investigation of Shape Memory Materials

Assoc. Prof. Elżbieta Alicja Pieczyska, Ph.D., Dr. Habil., Mech. Eng.

Department of Strength of Materials

Dynamical development of technology, a need for materials meeting the requirements in certain conditions, and environment protection make that recently a great interest is observed in smart and multifunctional materials. Such materials are able to adapt its property according to a change in a certain factor of environment, while the adaptation may be used as a driver for another physical factor. Virtually, it means that such materials can combine the property of sensor and actuator, assuring miniaturization of mass and dimensions, very important for applications. This group of materials comprises shape memory alloys (SMA), shape memory polymers (SMP) and shape memory composites (SMC).

The proposed course contains the fundamentals of the experimental mechanics, shape memory alloys, polymers and composites.

The course is dedicated to the students being interested in experimental investigation of new multifunctional materials properties.

Main topics:

1. Introduction to experimental mechanics.
2. Introduction to shape memory materials.
3. Application of shape memory alloys in engineering and medicine.
4. Experimental studies on shape memory alloys.
5. Thermo-mechanical properties of TiNi shape memory materials, subjected to various kinds of loadings.
6. Introduction to thermodynamics of martensitic forward and reverse transformations.
7. Why infrared camera is so useful tool in shape memory alloys study?
8. Problems to be solved in the future.

The total number of lecture hours: 20, laboratory exercises: 5 hours, self-teaching: 40, direct tutoring and consultations: 10 hours.

ECTS Points: 3



Apart of attending the above listed lectures and laboratory exercises, the doctoral students can deepen their knowledge and demonstrate own achievements by participating in the following seminars performed in the framework of scientific activity of the Institute, its departments and laboratories:

No	Supervised by	Subject
1.	Dr. habil. K. Kowalczyk-Gajewska	Institute Seminar on Mechanics in the Name of W. Olszak and A. Sawczuk
2.	Prof. J. Holnicki-Szulc	Seminar of the Laboratory of Safety Engineering
3.	Prof. W. Nasalski	Fundamentals of Nano-Photonics
4.	Prof. M. Glinicki	Seminar of the Laboratory of Fields of Strains
5.	Prof. A. Nowicki	Ultrasounds in Medicine
6.	Prof. Z. Kowalewski	Seminar of the Department of Strength of Materials
7.	Assoc. Prof. P. Kielczyński	Seminar of Acoustical Physics
8.	Assoc. Prof. M. Ekiel-Jeżewska, Prof. T. Lipniacki	Seminar of Mechanics and Physics of Fluids
9.	Prof. P. Dłużewski	Mechanics of Micro- and Nano-Structure of Materials
10.	Prof. H. Petryk	Seminar of Mechanics of Materials
11.	Prof. L. Jarecki	Seminar of the Laboratory of Physics of Polymers
12.	Prof. J. Sławianowski	Seminar of the Laboratory of Analytical Mechanics and Field Theory
13.	Assoc. Prof. P. Kowalczyk	Computer Methods in Mechanics
14.	Prof. J. Holnicki-Szulc, Prof. Cz. Bajer	Seminar of the Department of Intelligent Technologies
15.	Prof. L. Jarecki	Seminar of the Department of Theory of Continuous Media
16.	Prof. T. Lipniacki	Mathematical Models of Gene Expression and Regulatory Networks



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