The Wroclaw University of Science and Technology

Module handbook for Semester 2

6 MANDATORY MODULES		
1	Functional Analysis – Applications to boundary value problems	5 ECTS
2	Analytical Mechanics	5 ECTS
3	Modeling of Multibody Systems	5 ECTS
4	Design of Engineering Materials	5 ECTS
5	Probabilistic Methods in Engineering	5 ECTS
6	Artificial Intelligence in Engineering	5 ECTS

Module #1	FUNCTIONAL ANALYSIS – APPLICATIONS TO BOUNDARY VALUE PROBLEMS			
Information	Credit Points: 5 ECTS	Workload : 60 h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	Wojciech Puła, Marcin Chwała			
Contents	Examples of classical boundary value problems. Linear equations: canonical forms, separation of the variables (the Fourier method). Limitations of classical methods in the context of contemporary problems of mechanics. Metric spaces: exapmles, convergence in metric spaces, complete metric spaces, the Banach–Caccioppoli fixed-point theorem. Normed spaces, Banach spaces, Linear operators and functionals, bounded operators (Banach's theorem). Unitary spaces and their geometrical properties (Pythagorean theorem), Hilbert spaces, orthogonal expansions, the orthogonal projection theorem. Sobolev spaces. Functions of compact support, distributions, distribution derivatives, properties of H1 and H2 spaces. Generalized solutions of elliptic equations. Weak formulation of boundary value problems, the Lax-Milgram theorem, applications of the Lax-Milgram theorem. Methods of solving of variational equations: the method of least squares, the orthogonal projection method, the Galerkin method, the Ritz method.			
Examination	Written exam. In the case of any questions from both a student's or the instructor's side, an additional oral part can be required.			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course student will be able to: • demonstrate an understanding of weak formulation and variational formulation of the boundary value problems; • have a basic knowledge in mathematical bases of the finite element method (FEM) and the boundary element method (BEM); • demonstrate an understanding the basic concept of distributions and their derivatives; • be able to recognise a concept of metric spaces theory in various engineering problems.			

Module #2	ANALYTICAL MECHANICS			
Information	Credit Points : 5 ECTS	Workload : 60 h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	Piotr Kotowski			
Contents	Examples of dynamic systems. Constrains and their types, classification systems for the sake of the constrain types (holonomic systems), possible velocities and possible displacements. The fundamental problem of dynamics, virtual displacement, the notion of ideal constraints, the general equation of dynamics, the virtual work principle. The dynamic general equation for the rotational and planar motion of rigid body (examples). Generalized coordinates. Derivation of differential equations of motion by using the energy conservation law expressed in generalized coordinates (examples). Generalized forces. Configuration space. Lagrange's equations (of II type). Lagrange's equations (cont. examples, applications). Lagrangian. Linear systems with a finite number of degrees of freedom, matrix notation, conservative systems. Free vibrations of conservative systems: natural frequencies, modal matrices, mode shapes. Harmonically forced vibration, frequency characteristics, an example of oscillation analysis of two- degree- of- freedom system. The dynamics of a rigid body in general motion: the orientation, the recognition issue. Kinematics and dynamics of rigid body in case the spherical rotation about a fixed point (reminder of the course Mechanics II), the angular momentum in the general movement. The dynamic equations for general motion of rigid body (Euler's equation). Gyroscope (approximate theory). An outline of linear elastic particle collisions theory, inelastic collision rate. Variational approach of Lagrangian mechanics. The central Lagrange's equation. Fundamental integral mechanical principle (Hamilton's principle), (Lecture + Exercises)			
Examination	Written exam			
Requirement for examination	No specific requirement			
Learning outcomes	After completion of the course, the student: • is able to apply the virtual work principle and d'Alembert's principle for holonomic systems; • is able to derive the differential equations of motion of discrete dynamical systems by using Lagrange's equations; • can calculate the spectrum of natural frequencies and can determine the modal matrix for discrete conservative linear systems; • is able to analyze the dynamics of the gyro using the approximate theory (gyroscopic moment and reaction forces in the supports).			

Module #3	**MODELLING OF MULTI-BODY SYSTEMS**			
Information	Credit Points : 5 ECTS	Workload : 60 h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	Artur Handke, Michał Osiński			
Contents	An introduction to the principles of building a multibody models. Basics of modelling mechanisms in the MD. Adams system – modelling links, kinematic pairs, kinematic excitations. Basics of modelling mechanisms in the MD.Adams system –modelling loads and perform calculations and analysis of results. The test of modelling multibody system. Kinematic and kinetostatic analysis of linkage mechanisms – building virtual models. The analysis of kinematic and dynamic properties of the linkage mechanism (project). Analysis of gears (normal, planetary and differential) – principles of construction of virtual model. The analysis of kinematic and dynamic properties of the gears (project). Building models of manipulators – direct and inverse task of kinematics. Simulation researches of manipulators (project). Building models of spatial mechanisms – constraints, excitations. Modeling and simulations of spatial mechanisms (project). Modeling and simulations of spatial mechanisms – analysis of the results of calculations.			
Examination	Final test of knowledge and assement of project report			
Requirement for examination	No specific requirement			
Learning outcomes	After completion of the course, the student: • knows how to apply professional computer system for simulating and analyzing dynamic multibody; • is able to model the loads and the nature of work and the ability to analyze the mechanism of the results of the simulation of the multi-segmentis; • is able to compute the kinematics and dynamics of selected groups of mechanisms.			

Module #4	**DESIGN OF ENGINEERING MATERIALS**			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	Krzysztof Widanka			
Contents	Introduction to design of materials. Effect of chemical composition, processing and microstructure on properties of materials. Design of structure of material for specific working conditions. The role and significance of alloy phase diagrams in design of materials. Strengthening mechanisms in metals and alloys - theory and practice. The failure analysis - case study. Metal matrix composites - fundamentals in design. Criteria and quantitative methods of materials selection in engineering design.			
Examination	Final test of knowledge and assement of project report			
Requirement for examination	No specific requirement			
Learning outcomes	After completion of the course, the student: • has advanced knowledge on structure-properties relationship as well as on strengthening mechanisms in materials and their practical usage for material design of products; • knows the fundamentals and design philosophy of modern engineering materials and the criteria and methodology of materials selection and can participate in engineering design of products; • is able to design the materials structure in order to obtain the desired operational properties of product and to conduct the failure analysis of material and design the repair process for improvement of product durability.			

Module #5	**PROBABILISTIC METHODS IN ENGINEERING**			
Information	Credit Points : 5 ECTS	Workload : 60 h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	W. Puła, J. Pieczyńska-Kozłowska, M. Chwała			
Contents	Statistical probability approach. Basic facts in measure theory. Probability as a part of measure theory. Outline of most often used probability distributions (discrete and continuous). Limit theorems. Multidimensional distributions. Random processes – basic facts. Stationary random processes – correlation theory. Probabilistic modelling of engineering problems – examples. Estimation problems. The least square method, the maximum likelihood method. Bayesian approaches, basic and a concept of decision theory.			
Examination	A student will be mostly (75%) graded on the base of a written examination with an oral supplement (if necessary). Additionally her/his report on laboratory solved problems will be graded (25%).			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course student will be able to: • understand the measure's theory based concept of probability. • handle with the most common probability distributions and their statistical moments. • model simple engineering problems involving uncertain phenomena (parameters) by random variables and random functions. • have some skills in using most common estimation methods. • understand Bayesian inference application to engineering problems.			

Module #6	ARTIFICIAL INTELLIGENCE IN ENGINEERING			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 2nd semester
Institution in charge	Wrocław University of Science and Technology			
Instructors	Jan Bień, Mieszko Kużawa			
Contents	Learning the fundamental techniques used in computer tools with elements of artificial intelligence – applied in engineering. Expert systems and range of their applications in engineering (classification, architecture, evolution, directions of development). Technologies of knowledge acquisition and representation in computer systems. Knowledge bases and data bases. Expert functions in computer systems supporting decisions. Artificial neural networks – conception, architecture, training and testing techniques, applications. Fuzzy logic – fuzzy problems, linguistic variables, fuzzy reasoning procedures, testing, applications. Expert systems based on knowledge – design and implementation. Technology of hybrid networks in expert systems. Development of ability to design, computer implementation and testing of simple expert tools with elements of artificial intelligence. Technologies of knowledge acquisition and computer representation – examples from selected fields of engineering. Technology of artificial neural networks creation – introduction to computer software. Practical design, training and testing of artificial neural networks. Individual task (i.e.: conceptual design, knowledge acquisition, computer implementation and testing)			
Examination	Evaluating achievement will be conductive by colloquium on lecture at the end of semester and final laboratory report as well as active work in laboratory.			
Requirement for examination	No specific requirement			
Learning outcomes	After successful completion of the course, the student: • knows and understands methods of knowledge acquisition and representation in expert systems; • knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence; • has skill to independent acquisition of knowledge in engineering and to design, computer implementation and testing of simple expert tools with elements of artificial intelligence, supporting decisions in engineering; • is able to unaided solving the problems and is also prepared to a team-work (laboratory reports, laboratory exercises).			