STUDY MODULE DESCRIPTION FORM

Name of the module/subject **Numerical Analysis**		Code **1010115131010101980**
Field of study **Civil Engineering Extramural Second-cycle**	Profile of study (general academic, practical) **(brak)**	Year /Semester **2 / 3**
Elective path/specialty **Structural Engineering**	Subject offered in: **Polish**	Course (compulsory, elective) **obligatory**
Cycle of study: **Second-cycle studies**	Form of study (full-time,part-time) **part-time**	
No. of hours Lecture: **16** Classes: **10** Laboratory: **10** Project/seminars: **-**		No. of credits **3**
Status of the course in the study program (Basic, major, other) **(brak)**	(university-wide, from another field) **(brak)**	
Education areas and fields of science and art **technical sciences** **Technical sciences**		ECTS distribution (number and %) **3 100%** **3 100%**

Responsible for subject / lecturer:

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Prerequisites in terms of knowledge, skills and social competencies:

1	**Knowledge**	Modeling of interactions between solid bodies. Review of the most important computer methods in structural mechanics: SPH (Smoothed Particle Hydrodynamics), Multimaterial Finite Element Method, XFEM, DEM (Discrete Element Method) and others. Physical non-linearity: plasticity, non-linear elasticity in 1D and 3D terms. Linear and non-linear thermo-mechanics.
2	**Skills**	Solving advanced engineering problems with the use of a selected computer program. Solving problems of statics and dynamics of structures in the linear and nonlinear range of the finite element method.
3	**Social competencies**	Respect for the Polish language, understanding the need for lifelong learning and cooperation in the group, awareness of the need for self-education.

Assumptions and objectives of the course:

Gaining knowledge and skills related to the use of advanced numerical methods to solve complex engineering tasks in construction.

Study outcomes and reference to the educational results for a field of study

Knowledge:

1. The finite difference method applied to solving nonlinear partial differential equations. - [K_W01, K_W03]
2. The finite element method, its implicit and explicit approaches, applied to solving nonlinear structural. - [K_W03, K_W01]
3. Advanced numerical methods applied to nonlinear static and dynamic problems, contact problems, buckling and post-buckling stability analysis, basics of computational fluid dynamics. - [K_W04]

Skills:

1. Solving advanced practical problems by numerical methods. - [K_U04, K_U06]
2. Modeling by the finite element method advanced boundary and initial-boundary. - [K_U06, K_U04]
3. Usage of a commercial finite element program to practical complex engineering problems. - [K_U18]

Social competencies:

1. Respect for the Polish language, understanding the need for lifelong learning and cooperation in the group, awareness of the need for self-education. - [K_K01,K_K03]

Assessment methods of study outcomes

Student's work evaluation:

1. Written assessment of lectures at the end of the semester.
2. Written test of the exercises at the end of the semester.
3. Evaluation of the defense of the project carried out during laboratory classes.

Course description

Modeling of interactions between solid bodies.

Review of the most important computer methods in structural mechanics: SPH (Smoothed Particle Hydrodynamics), Multimaterial Finite Element Method, XFEM, MED (Discrete Element Method) and others. The use of computer simulations to determine the behavior of structures at exceptional loads, such as impacts, explosions, floods.

Physical non-linearity: plasticity, non-linear elasticity in 1D and 3D terms. Plastic surfaces and damage and destruction of material (review of selected criteria). Experimental basics to determine the properties of materials including dynamic ones. Sensitivity of material properties to deformation velocity and temperature. Constitutive models used in construction issues (for concrete, steel, rubber, ceramics, glass, wood).

Linear and non-linear thermo-mechanics. Overview of selected finite elements with temperature degrees of freedom. Sequential and coupled thermomechanical problems. Simulation of the behavior of the structure in conditions of elevated temperatures (fire)

Basic bibliography:

1. T. Łodygowski, W. Kąkol, Metoda elementów skończonych w wybranych zagadnieniach mechaniki konstrukcji inżynierskich, Skrypt PP, 1994, Nr 1779
2. T. Belytschko, W. K. Liu, B. Moran, Nonlinear Finite Elements for Continua and Structures, John Wiley and Sons, 2000
3. J.C. Simo, T.J.R. Hughes, Computational Inelasticity, Springer, 1998
4. T. Jankowiak, Kryteria zniszczenia betonu poddanego obciążeniom quasi-statycznym i dynamicznym, Monografia, Wydawnictwo Politechniki Poznańskiej, 2011, p. 138
5. T. Jankowiak, Wykorzystanie metod eksperymentalnych I symulacji komputerowych do określania właściwości materiałów przy dużej prędkości deformacji, Monografia, Wydawnictwo Politechniki Poznańskiej, 2016, p. 161

Additional bibliography:

1. J.N. Reddy, An Introduction to Nonlinear Finite Element Analysis, Oxford University Press, 2004
2. O.C.Zienkiewicz, R.L.Taylor, Finite Element Method, Elsevier 2005

Result of average student's workload

Activity	Time (working hours)
1. Participation in lectures	16
2. Participation in exercises	10
3. Participation in laboratories	10
4. Preparation for passing the lectures	34
5. Preparation to pass the exercises	15
6. Preparation for passing laboratories	20

Student's workload

Source of workload	hours	ECTS
Total workload	105	3
Contact hours	60	2
Practical activities	45	1