PROGRAM STUDIÓW

WYDZIAŁ: **Budownictwa Lądowego i Wodnego, Wydział Mechaniczny**
KIERUNEK STUDIÓW: **Advanced Solid Mechanics**
Przyporządkowany do dyscypliny: **D1 Inżynieria lądowa i transport (dyscyplina wiodąca)**
D2 Inżynieria mechaniczna
~~D3*~~ ……
~~D4*~~ ……
POZIOM KSZTAŁCENIA: ~~**studia pierwszego stopnia (licencjackie / inżynierskie)**~~ **/ drugiego stopnia /** ~~**jednolite magisterskie***~~
FORMA STUDIÓW: **stacjonarna /** ~~**niestacjonarna***~~
PROFIL: **ogólnoakademicki /** ~~**praktyczny**~~ *****
JĘZYK PROWADZENIA STUDIÓW: **angielski**
OBOWIĄZUJE OD CYKLU KSZTAŁCENIA: **2021/2022**

Zawartość:

*niepotrzebne skreślić

ZAKŁADANE EFEKTY UCZENIA SIĘ

Wydział: Budownictwa Lądowego i Wodnego, Wydział Mechaniczny
Kierunek studiów: Advanced Solid Mechanics
Poziom studiów: studia drugiego stopnia
Profil: ogólnoakademicki

Umiejscowienie kierunku

Dziedzina nauki: dziedzina nauk inżynieryjno-technicznych
Dyscyplina/dyscypliny w przypadku kilku dyscyplin proszę wskazać dyscyplinę wiodącą)
Inżynieria lądowa i transport - wiodąca

Objaśnienie oznaczeń:
P6U – charakterystyki uniwersalne odpowiadające kształceniu na studiach pierwszego stopnia - 6 poziom PRK*
P7U – charakterystyki uniwersalne odpowiadające kształceniu na studiach drugiego stopnia - 7 poziom PRK*

P6S – charakterystyki drugiego stopnia odpowiadające kształceniu na studiach pierwszego stopnia studiów - 6 poziom PRK *
P7S – charakterystyki drugiego stopnia odpowiadające kształceniu na studiach drugiego stopnia/ jednolitych magisterskich – 7 poziom PRK*
W – kategoria „wiedza”
U – kategoria „umiejętności”
K – kategoria „kompetencje społeczne”
K(*symbol kierunku*)_W1, K(*symbol kierunku*)_W2, K(*symbol kierunku*)_W3, …- efekty kierunkowe dot. kategorii „wiedza”
K(*symbol kierunku*)_U1, K(*symbol kierunku*)_U2, K(*symbol kierunku*)_U3, …- efekty kierunkowe dot. kategorii „umiejętności”
K(*symbol kierunku*)_K1, K(*symbol kierunku*)_K2, K(*symbol kierunku*)_K3, …- efekty kierunkowe dot. kategorii „kompetencje społeczne”
S(*symbol specjalności*)_W…, S(*symbol specjalności*)_W…, S(*symbol specjalności*)_W…, …- efekty specjalnościowe dot. kategorii „wiedza”
S(*symbol specjalności*)_U…, S(*symbol specjalności*)_U…, S(*symbol specjalności*)_U…, …- efekty specjalnościowe dot. kategorii „umiejętności”
S(*symbol specjalności*)_K…, S(*symbol specjalności*)_K…, S(*symbol specjalności*)_K…, …- efekty specjalnościowe dot. kategorii „kompetencje społeczne”
…._inż – efekty uczenia się umożliwiające uzyskanie kompetencji inżynierskich
Uwaga: efekty z kodem U są uzyskiwane wyłącznie na zajęciach o charakterze praktycznym.

Symbol kierunkowych efektów uczenia się	Opis efektów uczenia się dla kierunku studiów …….. Po ukończeniu kierunku studiów absolwent:	Odniesienie do charakterystyk PRK		
		Uniwersalne charakterystyki pierwszego stopnia (U)	Charakterystyki drugiego stopnia typowe dla kwalifikacji uzyskiwanych w ramach szkolnictwa wyższego (S)	
			Charakterystyki dla kwalifikacji na poziomach 6/7* PRK	Charakterystyki dla kwalifikacji na poziomach 6 i 7 PRK, umożliwiających uzyskanie kompetencji inżynierskich
WIEDZA (W)				
K2_W01	possess the bordered knowledge in the area of mathematics necessary to description and analysis of solid materials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W02	possess the necessary knowledge about the theoretical basis of numerical methods for modelling and analysis of engineering structures and mechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W03	knows the advanced topics in theoretical mechanics and structures	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W04	possess the essential knowledge in the area of continuum mechanics concept and mathematical description related to the mechanics and structure problems.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W05	possess grounded knowledge about the theoretical basis of constitutive laws.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W06	possess advanced knowledge in the area of dynamics and vibration aspects related to mechanics and structural engineering.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W07	knows the classification and the range of applications of computer programs supporting the analysis and design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W08	know principles of structure models, analysis and design of structural systems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W09	possesses the necessary knowledge about the interaction of structure with the environment	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W10	knows standard, guidelines and regulations relevant to the structure design	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2_W11	knows currently used, modern building materials and essential components of technologies and their production	**P7U_W**	**P7S_WG, P7S_WK**	**P7S_WG_INZ, P7S_WK_INZ**
K2_W12	knows the characteristics of analysis and structure optimisation as well as intricate structure system design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W13	knows the method of solving problems related to the theory of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W14	possessing advanced knowledge on structure-properties relationship for material design of products.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W15	knows the fundamentals and design philosophy of modern engineering materials.	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2_W16	extended knowledge of systems modelling	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
	achieves outcomes in the category of KNOWLEDGE in one of the following specialisations: • run in the English language - Mechanics of Structure (**K2S_MS_W**) (appendix I) - Mechanics of Materials (**K2S_MM_W**) (appendix II)			

UMIEJĘTNOŚCI (U)				
K2_U01	can use advanced specialist tools that support the design process related to the discipline of civil engineering and transport as well as mechanical engineering; know how to use information technologies for communication and knows how to choose software that supports the work of a designer	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U02	have the ability to solve engineering problems using the analytical or numerical tools	**P7U_U**	**P7S_UW**	
K2_U03	know how to establish directions for further education and follow the process of self-learning	**P7U_U**	**P7S_UK, P7S_UU**	
K2_U04	can use advanced methods of mechanics and the theory of structures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U05	can critically assess the results of numerical analysis	**P7U_U**	**P7S_UW , P7S_UU**	**P7S_UW_INZ**
K2_U06	can prepare a graphics project documentation	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U07	know how to assess threats related to projects and implement adequate safety principles, and can develop norms and standards of work and quality	**P7U_U**	**P7S_UW, P7S_UK, P7S_UO, P7S_UU**	**P7S_UW_INZ**
K2_U08	understand how to solve complex concepts in the area of chosen sections of mathematics, being the basis of advanced construction analysis methods; can choose tools (analytical or numerical) to solve engineering problems; can use chosen computer programs supporting modelling and design processes in civil engineering	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U09	can plan and carry laboratory experiments leading to quality assessment of applied materials and also the assessment of the strength	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U10	can acquire and apply information from literature, databases and other available sources to engineering activities in the field of design, operation of machinery and manufacturing techniques	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U11	is able to prepare a presentation on a selected topic	**P7U_U**	**P7S_UW, P7S_UK**	**P7S_UW_INZ**
K2_U12	know how to perform material selection and develop design assumptions based on performance requirements of structural elements or assemblies of machines and facilities	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U13	is able to, according to scientific principles, using scientific know-how to formulate and develop entry works of a research type leading to solving engineering problems as well as technological and organisational	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U14	is able to plan, prepare and carry out research and prepare elaborations which prepare him/her to take up research work	**P7U_U**	**P7S_UW, P7S_UK , P7S_UU**	**P7S_UW_INZ**
	achieves outcomes in the category of SKILLS in one of the following specialisations: • run in the English language - Mechanics of Structure (**K2S_MS_W**) (appendix I) - Mechanics of Materials (**K2S_MM_W**) (appendix II)			

KOMPETENCJE SPOŁECZNE (K)				
K2_K01	understand aware of the need to improve professional and personal competences continually; in the form of formal or informal education, it complements and expands knowledge in the field of modern processes and technologies related to civil engineering and transport as well as mechanical engineering	**P7U_K**	**P7S_KK**	
K2_K02	realises the significance and understands non-technical aspects and consequences of engineering activity and especially its influence on the natural environment and the related responsibility for decisions	**P7U_K**	**P7S_KK, P7S_KO**	
K2_K03	can work independently and cooperate in a group on given tasks; is responsible for the safety of his work as well as his team	**P7U_K**	**P7S_KK, P7S_KO**	
K2_K04	realises the significance of professional behaviour and obey the code of ethics; identifies correctly and solve dilemmas related to the profession; is able to set priorities that help in implementing a task set by himself or others	**P7U_K**	**P7S_KO, P7S_KR**	
K2_K05	can think and act in a creative and entrepreneurial way	**P7U_K**	**P7S_KO**	
K2_K06	realises the social role of technical university graduates and especially understands the need to formulate information and share it with society, e.g. through mass media, concerning achievements in environmental engineering and other aspects of engineering activity; makes attempts at understandably sharing such information and opinions, justifying different points of view.	**P7U_K**	**P7S_KK, P7S_KO, P7S_KR**	
K2_K07	acquires attention to the style of language and aesthetics of the work performed, including projects and reports	**P7U_K**	**P7S_KK, P7S_KO, P7S_KR**	

Załącznik I

Specjalność: Mechanics of Materials (MM)

Symbol specjalnościowych efektów uczenia się	Opis efektów uczenia się dla specjalności Konstrukcje Budowlane Po ukończeniu kierunku studiów absolwent:	Odniesienie do ogólnych charakterystyk efektów		
		Uniwersalna charakterystyka pierwszego stopnia (U)	Charakterystyki drugiego stopnia typowe dla kwalifikacji uzyskiwanych w ramach szkolnictwa wyższego (S)	
			Charakterystyki dla kwalifikacji na poziomach 7 PRK	Charakterystyki dla kwalifikacji na poziomach 6 i 7 PRK, umożliwiających uzyskanie kompetencji inżynierskich
WIEDZA (W)				
K2S_MM_W01	possess advanced knowledge of mathematics in the area of functional analysis, differential equations, probability distributions and boundary problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W02	knows the general concept of forces (active and inertia); the principle of virtual work, freedom in the free vibration range and mechanical behaviour under dynamic problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W03	uunderstood the kinematic and dynamical phenomena responsible for various vehicle behaviour	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W04	possesses extended knowledge of contemporary design and construction techniques based on the Finite Element Method	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W05	possesses the extended knowledge on properties relationship as well as on strength engineering mechanisms in materials and their practical usage for material design of products	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W06	knows the fundamentals and design philosophy of modern engineering materials and introduces topics of composite materials and nanomaterials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W07	knows the mathematical framework and the computational techniques of uncertainty quantification, reliability analyses and optimisation problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W08	possesses comprehensive knowledge of the operation and maintains the reliability and safety of technical systems and the management of renewal processes.	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**

K2S_MM_W09	knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W10	possesses extended knowledge in microstructural laboratory techniques and know the principles of geometrical and pours media according to mechanical morphology of microstructure and nanostructure	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W11	knows the assumptions of manufacturing and applications of various materials; possess the knowledge of variability behaviour of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W12	knows and understand the principles of analytical and computational approaches in the framework of micromechanics of problems in elasticity	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W13	possesses a well-developed knowledge of the fundamentals of fracture mechanics, defect criticality assessment and estimation of the "life" of a structure, as well as cyclic loading behaviour	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W14	knows the general concept of designing materials for biological issues	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W15	possesses the knowledge of the welding process	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W16	knows the multidisciplinary concept of rheology and fluid mechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W17	knows the concept of the designing process according to inventive engineering	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
UMIEJĘTNOŚCI (U)				
K2S_MM_U01	possesses the ability to analyses and solve the mathematical problems in the area of functional analysis, the modal matrix for discrete linear systems and the virtual work principle	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U02	can apply advanced computational techniques, including simulation and dynamics analysis, compute the kinematics and dynamics groups of mechanisms	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U03	can estimate fundamental parameters of fracture mechanics and use experimental methods for fatigue lifetime predictions	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U04	possesses the ability to design the materials by chosen components of objects in the field of general construction problems and carry out research of components	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**

K2S_MM_U05	understand and use the advanced methods of studying the difference between the properties of nanomaterials and nanostructures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U06	possesses the ability to solve tasks related to chosen theoretical issues to design process	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
KOMPETENCJE SPOŁECZNE (K)				
K2S_MM_K01	can objectively evaluate the arguments and rationally explain and justify own point of view	**P7U_K**	**P7S_KK**	
K2S_MM_K02	possessing collaboration skills and able to lead the research teams in the engineering design process	**P7U_K**	**P7S_KK**	
K2S_MM_K03	possessing the skills of objective evaluation of arguments and formulation of rational conclusions concerning the use of engineering materials and processes	**P7U_K**	**P7S_KK**	
K2S_MM_K04	learn to think analytically, precisely formulate problems and solve them within a specific theory	**P7U_K**	**P7S_KK**	
K2S_MM_K05	can search for information and to critical review	**P7U_K**	**P7S_KK**	
K2S_MM_K06	understand aware of the necessity of needing the expanding knowledge	**P7U_K**	**P7S_KK**	
K2S_MM_K07	is aware of the necessity of verifying the computational approach used and the correctness of the results obtained.	**P7U_K**	**P7S_KK**	

Załącznik II

Specjalność: Mechanics of Structure (MS)

Symbol specjalnościowych efektów uczenia się	Opis efektów uczenia się dla specjalności Konstrukcje Budowlane Po ukończeniu kierunku studiów absolwent:	Odniesienie do ogólnych charakterystyk efektów		
		Uniwersalna charakterystyka pierwszego stopnia (U)	Charakterystyki drugiego stopnia typowe dla kwalifikacji uzyskiwanych w ramach szkolnictwa wyższego (S)	
			Charakterystyki dla kwalifikacji na poziomach 7 PRK	Charakterystyki dla kwalifikacji na poziomach 6 i 7 PRK, umożliwiających uzyskanie kompetencji inżynierskich
WIEDZA (W)				
K2S_MS_W01	possess advanced knowledge of mathematics in the area of functional analysis, differential equations, probability distributions and boundary problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W02	knows the general concept of structure and mechanical behaviour under dynamic forces	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W03	possesses extended knowledge of contemporary design and construction techniques based on the Finite Element Method	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W04	know the principles of geometrical and pours media according to mechanical morphology of microstructure	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W05	get the introduction to topics of composite materials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W06	knows the mathematical framework and the computational techniques of uncertainty quantification, reliability analyses and optimisation problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W07	knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W08	possess developed knowledge in the mechanics of soil materials and geotechnical structure design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W09	possesses the knowledge for steel construction design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W10	possess the knowledge of variability behaviour of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W11	knows and understand the principles of analytical and computational approaches in the framework of micromechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**

K2S_MS_W12	possesses a well-developed knowledge of the fundamentals of fracture mechanics, defect criticality assessment and estimation of the "life" of a structure, as well as cyclic loading behaviour	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
UMIEJĘTNOŚCI (U)				
K2S_MS_U01	possesses the ability to analyse and solve mathematical problems in the area of functional analysis, reliability analysis and optimisation problems	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U02	can apply advanced computational techniques, including optimisation ones, to model and calculate structures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U03	can design chosen elements of geotechnical structures taking into consideration soil variability problems	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U04	can design and research components and materials	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U05	can design chosen components of objects concerning problems of general construction	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U06	can formulate and possesses the ability to solve tasks related to chosen theoretical issues to design process	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
KOMPETENCJE SPOŁECZNE (K)				
K2S_MS_K01	can objectively evaluate the arguments and rationally explain and justify own point of view	**P7U_K**	**P7S_KK**	
K2S_MS_K02	possessing collaboration skills and able to lead the research teams in the engineering design process	**P7U_K**	**P7S_KK**	
K2S_MS_K03	possessing the skills of objective evaluation of arguments and formulation of rational conclusions concerning the use of engineering materials and processes	**P7U_K**	**P7S_KK**	
K2S_MS_K04	learn to think analytically, precisely formulate problems and solve them within a particular theory	**P7U_K**	**P7S_KK**	
K2S_MS_K05	can search for information and to critical review	**P7U_K**	**P7S_KK**	
K2S_MS_K06	understand aware of the need to expand the knowledge	**P7U_K**	**P7S_KK**	
K2S_MS_K07	is aware of the necessity of verifying the computational approach used and the correctness of the results obtained.	**P7U_K**	**P7S_KK**	

Zał. nr 4 do ZW 121/2020
Zał. nr 2 do programu studiów

OPIS PROGRAMU STUDIÓW

WYDZIAŁ: Budownictwa Lądowego i Wodnego, Wydział Mechaniczny

KIERUNEK: ***Advanced Solid Mechanics***

POZIOM KSZTAŁCENIA: II stopień, studia magisterskie

FORMA STUDIÓW: stacjonarna

PROFIL: ogólnoakademicki

SPECJALNOŚĆ: Mechanics of Materials (MM), Mechanics of Structure (MS)

JĘZYK STUDIÓW: angielski

OBOWIĄZUJE OD CYKLU KSZTAŁCENIA: 2021/2022

1. Opis ogólny

1.1. Liczba semestrów:	***4***
1.2. Całkowita liczba punktów ECTS konieczna do ukończenia studiów na danym poziomie:	***120***
1.3. Łączna liczba godzin zajęć:	
Mechanics of Materials (MM)	***1022***
Mechanics of Structure (MS)	***1022***

1.4. Wymagania wstępne (w szczególności w przypadku studiów II stopnia):

An applicant for second level studies in Advanced Solid Mechanics in the Wroclaw University of Science and Technology must have qualifications of first level studies in science or technical sciense with minimum 180 ECTS or an equivalent first academic degree from an internationally recognized university. An applicant should be competent in continuing education at second level studies in this faculty. Candidates applying for second level studies in Advanced Solid Mechanics must:

- possess knowledge from selected fields of mathematics and physics which enables the understanding of the physical basis of construction and also the formulation and solving of simple problems in the area of civil and mechanical engineering;

- possess knowledge from chemistry which enables the understanding of the basis of chemical properties of the materials used in civil and mechanical engineering;

- be able to read and understand architectural, constructional, geodesy, and mechanical drawings and make proper project documentation in a graphical environment on selected CAD software;

- possess knowledge and be competent in the area of structural mechanics and strength of materials;

- possess knowledge and ability to apply the principles of structural mechanics and bar construction analysis in the areas of statics, dynamics and stability;

- be able to apply appropriate computational models and carry out structural mechanic analysis and mechanical analyses of simple structures;

- possess skills in the area of interpretation, presentation and documentation of simple experiments and also in the area of presentation and documentation of the results of task implementation with project characteristics.

The principles for verifying the competencies of candidates are determined by the appropriate resolutions of the Faculty Council

1.5. Tytuł zawodowy nadawany po zakończeniu studiów:	***magister inżynier***

1.6. Sylwetka absolwenta, możliwości zatrudnienia:

After finishing second level studies in the Advanced Solid Mechanics, a graduate, using his acquired knowledge and skills is ready to make decisions regarding the appropriate usage of materials, construction design and construction projects. Knows the current trends in the design and execution of building projects. Uses principles of occupational health and safety. Is able to design buildings, knows the principles of structural mechanics and is able to formulate, create, and then use the appropriate computational models of complex engineering structures. Can make and read technical drawings, recognize geodesy and cartography documentations and manage construction works. Is able to formulate and solve new engineering, technical and organizational issues related to civil and mechanical engineering. Can use modern computer aided technics in the design process. Can critically select arguments supporting collective decisions related to the execution of tasks in civil engineering. Is able to formulate and publish reports on the progress of carried out works. Is able to solve complex problems, including application of independent observation, measurement and modelling methods.

Is able to work in a team and supervise a team's duties. Is responsible for the safety of a supervised team. Is aware of the need to improve his professional and personal competence. Follows ethical rules. Knows and uses the principles of construction law.

Has language skills in the fields of science and scientific disciplines relevant to the studied faculty and requirements for B+ level of the Common European Framework of Reference for Languages. Is prepared to continue his education at third level studies. Graduates are able to: solve complex design, organizational and technological issues, formulate and carry out research programs, run projects of international scope, continue their education and participate in research and disciplines directly related to civil engineering and mechanical engineering, constantly update their qualifications and knowledge and also manage large groups of people. Graduates are qualified to take a job in: construction and design offices, executive enterprises, research institutes and development centres and also guidence institutions disseminating knowledge from civil and mechanical engeneering. Futhermore, graduates of each specialization achieve additional extended competence refering to the education outcomes of their specialization:

A graduate of Mechanics of Materials possesses enriched knowledge and advanced skills, including: the ability to analyses and solve the mathematical problems in the area of functional analysis, the modal matrix for discrete linear systems and the virtual work principle; applying advanced computational techniques, including simulation and dynamics analysis, compute the kinematics and dynamics groups of mechanisms; can estimate fundamental parameters of fracture mechanics and use experimental methods for fatigue lifetime predictions; possesses the ability to design the materials by chosen components of objects in the field of general construction problems and carry out research of components; understand and use the advanced methods of studying the difference between the properties of nanomaterials and nanostructures.

A graduate of Mechanics of Structures possesses enriched knowledge and advanced design skills, including: possesses the ability to analyse and solve mathematical problems in the area of functional analysis, reliability analysis and optimisation problems; can apply advanced computational techniques, including optimisation ones, to model and calculate structures; can design chosen elements of geotechnical structures taking into consideration soil variability problems; can design and research components and materials; can design chosen components of objects concerning problems of general construction; can formulate and possesses the ability to solve tasks related to chosen theoretical issues to design process.

1.7. Możliwość kontynuacji studiów: ***szkoła doktorska***

1.8. Wskazanie związku z misja Uczelni mi strategia jej rozwoju:

The Advanced Solid Mechanics on second level studies with specializations carried out during full-time studies: Mechanics of Structures and Mechanics of Materials; Civil Engineering (conducted in English) which is run according to the mission and development strategy of Wroclaw University of Science and Technology. Studies on the Civil Engineering Faculty and Mechanical Eginerring Facoulty are closely related to scientific and research works carried out at the Civil Engineering Facoulty and Mechanical Engineering Facoulty by the chairs and divisions.

2. Opis szczegółowy

2.1. Całkowita liczba efektów uczenia się w programie studiów:

kierunkowe	*W (wiedza) =*	*U (umiejętności) =*	*K (kompetencje) =*	*W + U + K =*
	16	***14***	***7***	***37***
specjalnościowe				
Mechanics of Materials (MM	***17***	***6***	***7***	***30***
Mechanics of Structure (MS)	***12***	***6***	***7***	***25***

2.2. Dla kierunku studiów przyporządkowanego do więcej niż jednej dyscypliny – liczba efektów uczenia się przypisana do dyscypliny:

D1 Inżynieria lądowa i transport (wiodąca), (liczba ta musi być większa od połowy całkowitej liczby efektów uczenia się)	***31***
D2 - Inżynieria mechaniczna	***30***
D3 -	
D4 -	

2.3. Dla kierunku studiów przyporządkowanego do więcej niż jednej dyscypliny – procentowy udział liczby punktów ECTS dla każdej z dyscyplin:

D1 Inżynieria lądowa i transport (wiodąca)	*% punktów ECTS:*	***54.9%***
D2 - Inżynieria mechaniczna		***45.1%***
D3 -		
D4 -		

2.4a. Dla kierunku studiów o profilu ogólnoakademickim – liczba punktów ECTS przypisana zajęciom związanym z prowadzoną w Uczelni działalnością naukową w dyscyplinie lub dyscyplinach, do których przyporządkowany jest kierunek studiów - DN (musi być większa niż 50 % całkowitej liczby punktów ECTS z p. 2.1): ***120***

2.4b. Dla kierunku studiów o profilu praktycznym - liczba punktów ECTS przypisana zajęciom kształtującym umiejętności praktyczne (musi być większa niż 50 % całkowitej liczby punktów ECTS z p. 2.1): -

2.5. Zwięzła analiza zgodności zakładanych efektów kształcenia z potrzebami rynku pracy

The education program aims to comprehensively prepare highly qualified engineering technical staff in the widely considered field of civil engineering and mechanical engineering. Due to the flexibillity of mobility paths students have their autonomy in the developement of the learing process which is beneficial for their proffesional career. Universal basic knowledge enables graduates to flexibly adapt to the changing needs of the labour market. Each specialization (Mechanics of Structures and Mechanics of Materials) prepares graduates for research and science work, and gives graduates the opportunity to establish cooperation with international construction companies. The basis of all specializations is knowledge and skills which enable graduates to obtain appropriate professional qualifications.

2.6. Łączna liczba punktów ECTS, którą student musi uzyskać na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich lub innych osób prowadzących zajęcia i studentów (wpisać sumę punktów ECTS dla kursów/ grup kursów oznaczonych kodem BU1):

Mechanics of Materials (MM)	***45.6***

Mechanics of Structure (MS)	***45.4***
2.7. Łączna liczba punktów ECTS, którą student musi uzyskać w ramach zajęć z zakresu nauk podstawowych	
Liczba punktów ECTS z przedmiotów obowiązkowych:	***10***
Liczba punktów ECTS z przedmiotów wybieralnych:	***0***
Łączna liczba punktów ECTS:	***10***
2.8. Łączna liczba punktów ECTS, którą student musi uzyskać w ramach zajęć o charakterze praktycznym, w tym zajęć laboratoryjnych i projektowych (wpisać sumę punktów ECTS kursów/grup kursów oznaczonych kodem P)	
Mechanics of Materials (MM)	***61.6***
Mechanics of Structure (MS)	***61.8***
2.9. Minimalna liczba punktów ECTS , którą student musi uzyskać, realizując bloki kształcenia oferowane na zajęciach ogólnouczelnianych lub na innym kierunku studiów (wpisać sumę punktów ECTS kursów/grup kursów oznaczonych kodem O):	***10***
2.10. Łączna liczba punktów ECTS, którą student może uzyskać, realizując bloki wybieralne (min. 30 % całkowitej liczby punktów ECTS):	***-***

4. Lista bloków zajęć:

Oznaczenia:

[1]BU – liczba punktów ECTS przypisanych zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia

[2]Tradycyjna – T, zdalna – Z

[3]Egzamin – E, zaliczenie na ocenę – Z. W grupie kursów po literze E lub Z wpisać w nawiasie formę kursu końcowego (w, c, l, s, p)

[4]Kurs/ grupa kursów Ogólnouczelniany – O

[5]Kurs/ grupa kursów związany/-a z prowadzoną dział. naukową – DN

[6] Kurs / grupa kursów o charakterze praktycznym – P. W grupie kursów w nawiasie wpisać liczbę punktów ECTS dla kursów cząstkowych o charakterze praktycznym

[7] KO – kształcenia ogólnego, PD – podstawowy, K – kierunkowy, S – specjalnościowy

W – wybieralny, Ob – obowiązkowy

CNPS – całkowity nakład pracy studenta; ZZU – zajęcia zorganizowane; 1 ECTS = 30 h NPS

Uwaga: efekty z kodem U są uzyskiwane wyłącznie na zajęciach o charakterze praktycznym.

Advanced Solid Mechanics (ASM) -lista bloków dla:

Mechanics of Structure (MS)

Mechanics of Materials (MM)

4.1. Lista bloków zajęć obowiązkowych

4.1.2. Lista bloków z zakresu nauk podstawowych

4.1.2.1. Blok *Matematyka* (min. 5 ECTS)

L.p.	Kod kursu / grupy kursów	Nazwa kursu / grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1		Mathematical Tools for Engineering	1.33333					K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	20	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.3333					20	60	2	2	1	T, Z	Z	O	2	1.3	PD	Ob.
					0.667				10	30	1	1		T, Z	Z		1	0.7	PD	Ob.
		Razem	1.33333	1.3333	0.667	0	0		50	150	5	5	3				5	2		

4.1.2.2. Blok Numerical Methods (min. 5 ECTS)

L.p.	Kod kursu / grupy kursów	Nazwa kursu / grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1		Numerical Methods in Engineering	1.06667					K2_W02, K2_W07, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.0667					16	30	1	1	1	T, Z	Z	O	1	0.6	PD	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	PD	Ob.
		Razem	1.06667	1.0667	0	1.2	0		50	150	5	5	3				5	1.3		

Razem dla bloków obowiązkowych kształcenia podstawowego:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć	Liczba punktów ECTS zajęć BU[1]
w	ć	l	p	s					
2.4	2.4	0.667	1.2	0	100	300	10	10	6.0

Liczba punktów ECTS zajęć P
3.3

4.1.3. Lista bloków kierunkowych

L.p.	Kod kursu / grupy kursów	Nazwa kursu / grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1		Continuum Mechanics	1.06667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	3	T, Z	Z		2		K	Ob.
				1.6					24	60	2	2	2	T, Z	Z		2	1.3	K	Ob.
					0.533				8	30	1	1		T, Z	Z		1	0.7	K	Ob.
2		Constitutive Laws	1.46667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W05, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	22	60	2	2	2	T, Z	Z		2		K	Ob.
				1.2					18	60	2	2	2	T, Z	Z		2	0.4	K	Ob.
						0.6667			10	30	1	1		T, Z	Z		1	0.7	K	Ob.
3		Dynamics and Vibrations	1.06667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W06, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	30	1	1	2	T, Z	Z		1		K	Ob.
				0.9333					14	60	2	2	1	T, Z	Z		2	0.7	K	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	K	Ob.
4		Experimental Mechanics	0.8					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	12	30	1	1	1	T, Z	Z		1		K	Ob.
				0.5333					8	30	1	1	1	T, Z	Z		1	1	K	Ob.
					0.8				12	60	2	2	1	T, Z	Z		2	1.3	K	Ob.
						1.6			24	30	1	1	1	T, Z	Z		1	0.7	K	Ob.
5	**ASB000152**	Functional Analysis - Applications To Boundary Value Problems (CE) Analiza funkcjonalna – zastosowania do problemów wartości brzegowych	2					K2_W01, K2_W03, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	E		3		K	Ob.
				2					30	60	2	2	0.6	T, Z	Z		2	1	K	Ob.
6	**ASM003002**	Analytical Mechanics (ME) Mechanika Analityczna	2					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	30	60	2	2	0.6	T, Z	E		2		K	Ob.
				1					15	30	1	1	0.7	T, Z	Z		1	2	K	Ob.
					1				15	60	2	2	0.6		Z		2	2	K	Ob.
7	**ASM003006**	Modeling of Multibody Systems (ME) Modelowanie układów wielczłonowych				4		K2_W02, K2_W04, K2_W06, K2_W07, K2_W08, K2_W13, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	60	150	5	5	1.4	T, Z	Z		5	3	K	Ob.
8	**ASM003003**	Design of Engineering Materials (ME) Projektowanie Materiałów Inżynierskich	2					K2_W01, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
						2			30	60	2	2	0.7	T, Z	Z		2	1	K	Ob.
9	**ASB000252**	Probabilistic Methods in Engineering (CE) Metody probabilistyczne w inżynierii	2					K2_W01, K2_W02, K2_W03, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	K	Ob.
							1		15	30	1	1	0.6	T, Z	Z		1		K	Ob.
10	**ASB000352**	Artificial Intelligence in Engineering (CE) Sztuczna inteligencja w inżynierii	2					K2_W02, K2_W07, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.

					2				30	60	2	2	0.6	T, Z	Z		2	2	K	Ob.
	Razem	14.4	8.2667	4.333	9.4667	1			562	1500	50	50	25				50	19.5		

4.1.4. Lista bloków specjalnościowych

Specialization: Mechanics of Structure (MS)

L.p.	Kod kursu / grupy kursów	Nazwa kursu / grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB030553**	Risk Assessment in Geotechnics - Implementation of Random Field Theory (CE) Ocena ryzyka w geotechnice – zastosowania teorii pól losowych	3					K2_W01, K2_W02, K2_W03, K2_W07, K2_W09, K2_W10, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W06, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	45	90	3	3	0.6	T, Z	Z		3		S	Ob.
					1				15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
2	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
3	**ASB030653**	Advanced Geoengineering (CE) Zaawansowana Geoinżynieria	2					K2_W04, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W02, K2S_MS_W03, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	30	1	1	0.6	T, Z	Z		1		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
							1		15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.

5	**ASB030753**	Advanced Steel-Concrete Composite Constructions (CE) Zaawansowane konstrukcje zespolone stalowo-betonowe	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W02, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W09, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
							2		30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
6	**ASB030853**	Advanced Soil Mechanics and Soil Structure Interaction (CE) Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W09, K2_W10, K2_W11, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
7	**ASB029954**	Master thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Razem	13	1	6	1	3		360	1800	60	60	14.8				60	38.8		

Specialization: Mechanics of Materials (MM)

L.p.	Kod kursu / grupy kursów	Nazwa kursu / grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB020553**	Laboratory Identification of Composite Microstructure Properties (CE) Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów	1					K2_W02, K2_W03, K2_W04, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W14, K2S_MM_W16, K2S_MM_U03, K2S_MM_U04, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	30	1	2	0.6	T, Z	Z		2		S	Ob.
					2				30	90	3	3	1	T, Z	Z		3	2	S	Ob.
							1		15	30	1			T, Z	Z				S	Ob.
2	**ASM003001**	Advanced Nano-Materials (ME) Zaawansowane nanomateriały	2					K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W17, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_U04, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3		T, Z	Z		3		S	Ob.
					2				30	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
						2			30	30	1	1	0.6				1	1	S	
3	**ASM003007**	Reliability and Maintenance Theory and Engineering (ME) Teoria i inżynieria niezawodności i eksploatacji	2					K2_W01, K2_W03, K2_W09, K2_W10, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W07, K2S_MM_W08, K2S_MM_W09, K2S_MM_U03, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
5	**ASM003005**	Inventive Engineering (ME) Inżynieria wynalazczości	2					K2_W02, K2_W07, K2_W11, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03,	30	60	2	2		T, Z	Z		2		S	Ob.

						1		K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W17, K2S_MM_U02, K2S_MM_U03, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	90	3	3	0.6	T, Z	Z		3	1	S	Ob.
6	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
7	**ASB029954**	Master thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Razem	11	1	7	4	1		360	1800	60	60	14.6				60	39		

4.3. Blok praktyk

nie dotyczy	**-**

4.4. Blok praca dyplomowa (uchwała Rady Wydziały w sprawie regulaminów realizacji prac dyplomowych oraz dyplomowania KSIĘGA PROCEDUR na Wydziale Budownictwa Lądowego i Wodnego Politechniki Wrocławskiej. Procedura dyplomowania Pr 8/4. Zatwierdzona przez Dziekana Wydziału BLiW PWr w dniu 22.09.2020

Typ pracy dyplomowej	**magisterska**	
Liczba semestrów pracy dyplomowej	**Liczba punktów ECTS**	**Kod**
1	**18**	**ASB029954**
Charakter pracy dyplomowej		
Praca dyplomowa magisterska realizowana na studiach II stopnia może być studialna, studialno-projektowa lub eksperymentalno-projektowa. Powinna ona wykazać umiejętności dyplomanta nabyte w czasie studiów, jej zakres nie powinien wykraczać poza zagadnienia zawarte w programach poszczególnych przedmiotów, zarówno kierunkowych, jak i specjalnościowych z uwzględnieniem zagadnień zawartych w efektach kształcenia dla studiów I stopnia.		
Liczba punktów ECTS BU[1]	**7**	
Liczba punktów ECTS DN[5]	**30**	

5. Sposób weryfikacji zakładanych efektów ksztalcenia

Typ zajęć	**Sposoby weryfikacji zakładanych efektów kształcenia**
wykład	np. egzamin, kolokwium
ćwiczenia	np. test, kolokwium, prezentacja
laboratorium	np. wejściówka, sprawozdanie z laboratorium, prezentacja
projekt	np. obrona projektu
seminarium	np. udział w dyskusji, prezentacja tematu, esej
praktyka	np. raport z praktyki
praca dyplomowa	przygotowana praca dyplomowa, obrona, egzamin dyplomowy

6. Zakres egzaminu dyplomowego

Ogólne zasady organizowania i przebiegu egzaminu dyplomowego określa §25 Regulaminu studiów wyższych w Politechnice Wrocławskiej.

Egzamin składa się z dwóch części:
a) przedstawienie tematyki pracy dyplomowej, metod jej realizacji i uzyskanych wyników oraz obrona pracy dyplomowej poprzez udzielenie przez studenta odpowiedzi (ustnej lub rysunkowej) na ustne pytania członków Komisji Egzaminów Dyplomowych zadawane w trakcie lub bezpośrednio po prezentacji pracy, a dotyczące wyłącznie treści pracy oraz zastosowanej metodyki;
b) egzamin ustny z zakresu przedmiotów kierunkowych i specjalnościowych, dotyczący sprawdzenia wiedzy studenta w zakresie podanym w programie nauczania danej specjalności studiów drugiego stopnia. Studentowi zadawane są co najmniej trzy pytania, z których dwa dotyczą przedmiotów kierunkowych, a co najmniej jedno z przedmiotów specjalizujących. Program nauczania każdej specjalności jest zamieszczony na stronie internetowej Wydziału.
Egzamin nie może obejmować pytań z zagadnień, które nie znajdowały się w programie studiów kończonych przez egzaminowanego studenta.

7. Wymagania dotyczące terminu zaliczenia określonych kursów/grup kursów lub wszystkich kursów w poszczególnych blokach

Zgodnie z regulaminem studiów wyższych w Politechnice Wrocławskiej.

8. Plan studiów (załącznik nr 3)

Zaopiniowane przez właściwy organ uchwałodawczy Samorządu Studenckiego:

.....	.....
Data	Imię, nazwisko i podpis przedstawiciela studentów
.....	.....
Data	Podpis Dziekana Wydziału / Dyrektora Filii

Załącznik nr 5 do ZW 121/2020
Załącznik nr 3 do programu studiów

PLAN STUDIÓW

WYDZIAŁ: Budownictwa Lądowego i Wodnego, Wydział Mechaniczny

KIERUNEK: ***Advanced Solid Mechanics***

POZIOM KSZTAŁCENIA: II stopień, studia magisterskie

FORMA STUDIÓW: stacjonarna

PROFIL: ogólnoakademicki

SPECJALNOŚĆ: Mechanics of Materials (MM), Mechanics of Structure (MS)

JĘZYK STUDIÓW: angielski

OBOWIĄZUJE OD CYKLU KSZTAŁCENIA: 2021/2022

1. **Zestaw kursów / grup kursów obowiązkowych i wybieralnych w układzie semestralnym**

Oznaczenia:

[1]BU – liczba punktów ECTS przypisanych zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia

[2]Tradycyjna – T, zdalna – Z

[3]Egzamin – E, zaliczenie na ocenę – Z. W grupie kursów po literze E lub Z wpisać w nawiasie formę kursu końcowego (w, c, l, s, p)

[4]Kurs/ grupa kursów Ogólnouczelniany – O

[5]Kurs/ grupa kursów związany/-a z prowadzoną dział. naukową – DN

[6] Kurs / grupa kursów o charakterze praktycznym – P. W grupie kursów w nawiasie wpisać liczbę punktów ECTS dla kursów cząstkowych o charakterze praktycznym

[7] KO – kształcenia ogólnego, PD – podstawowy, K – kierunkowy, S – specjalnościowy

W – wybieralny, Ob – obowiązkowy

CNPS - calkowity nakład pracy studenta; ZZU - zajęcia zorganizowane; 1 ECTS = 30 h NPS

Uwaga: efekty z kodem U są uzyskiwane wyłącznie na zajęciach o charakterze praktycznym.

Advanced Solid Mechanics (ASM) -lista bloków dla:

Mechanics of Structure (MS)

Mechanics of Materials (MM)

Semestr 1 * WYMIAR GODZIN PRZELICZONY NA SYSTEM 15 TYGODNI

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1		Mathematical Tools for Engineering	1.3333					K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	20	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.333					20	60	2	2	1	T, Z	Z	O	2	1.3	PD	Ob.
					0.667				10	30	1	1		T, Z	Z		1	0.7	PD	Ob.
2		Numerical Methods in Engineering	1.0667					K2_W02, K2_W07, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.067					16	30	1	1	1	T, Z	Z	O	1	0.6	PD	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	PD	Ob.
3		Continuum Mechanics	1.0667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	3	T, Z	Z		2		K	Ob.
				1.6					24	60	2	2	2	T, Z	Z		2	1.3	K	Ob.
					0.533				8	30	1	1		T, Z	Z		1	0.7	K	Ob.
4		Constitutive Laws	1.4667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W05, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	22	60	2	2	2	T, Z	Z		2		K	Ob.
				1.2					18	60	2	2	2	T, Z	Z		2	0.4	K	Ob.
						0.667			10	30	1	1		T, Z	Z		1	0.7	K	Ob.
5		Dynamics and Vibrations	1.0667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W06, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	30	1	1	2	T, Z	Z		1		K	Ob.
				0.933					14	60	2	2	1	T, Z	Z		2	0.7	K	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	K	Ob.
6		Experimental Mechanics	0.8					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	12	30	1	1	1	T, Z	Z		1		K	Ob.
				0.533					8	30	1	1	1	T, Z	Z		1	1	K	Ob.
					0.8				12	60	2	2	1	T, Z	Z		2	1.3	K	Ob.
						1.6			24	30	1	1	1	T, Z	Z		1	0.7	K	Ob.
		Razem	6.8	6.667	2	4.667	0		302	900	30	30	22				30	10.8		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]
w	ć	l	p	s					
6.8	6.667	2	4.667	0	302	900	30	30	22

Liczba punktów ECTS zajęć P
10.8

Semestr 2

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB000152**	Functional Analysis - Applications To Boundary Value Problems (CE) Analiza funkcjonalna – zastosowania do problemów wartości brzegowych	2					K2_W01, K2_W03, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	E		3		K	Ob.
				2					30	60	2	2	0.6	T, Z	Z		2	1	K	Ob.
2	**ASM003002**	Analytical Mechanics (ME) Mechanika Analityczna	2					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	30	60	2	2	0.6	T, Z	E		2		K	Ob.
				1					15	30	1	1	0.7	T, Z	Z		1	2	K	Ob.
					1				15	60	2	2	0.6		Z		2	2	K	Ob.
3	**ASM003006**	Modeling of Multibody Systems (ME) Modelowanie układów wielczłonowych				4		K2_W02, K2_W04, K2_W06, K2_W07, K2_W08, K2_W13, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	60	150	5	5	1.4	T, Z	Z		5	3	K	Ob.
4	**ASM003003**	Design of Engineering Materials (ME) Projektowanie Materiałów Inżynierskich	2					K2_W01, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
						2			30	60	2	2	0.7	T, Z	Z		2	1	K	Ob.
5	**ASB000252**	Probabilistic Methods in Engineering (CE) Metody probabilistyczne w inżynierii	2					K2_W01, K2_W02, K2_W03, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	K	Ob.
							1		15	30	1	1	0.6	T, Z	Z		1		K	Ob.
6	**ASB000352**	Artificial Intelligence in Engineering (CE) Sztuczna inteligencja w inżynierii	2					K2_W02, K2_W07, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	2	K	Ob.
		Razem	10	4	3	6	1		360	900	30	30	8.8				30	12.0		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
10	4	3	6	1	360	900	30	30	8.8	12.0

Razem narastająco:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
16.8	10.67	5	10.67	1	662	1800	60	60	30.8	22.8

Specialization: Mechanics of Structure (MS)

Semestr 3

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[3] kursu/ grupy kursów	Sposób[7] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[2]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB030553**	Risk Assessment in Geotechnics - Implementation of Random Field Theory (CE) Ocena ryzyka w geotechnice – zastosowania teorii pól losowych	3					K2_W01, K2_W02, K2_W03, K2_W07, K2_W09, K2_W10, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W06, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	45	90	3	3	0.6	T, Z	Z		3		S	Ob.
					1				15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
2	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
3	**ASB030653**	Advanced Geoengineering (CE) Zaawansowana Geoinżynieria	2					K2_W04, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W02, K2S_MS_W03, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	30	1	1	0.6	T, Z	Z		1		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
							1		15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09,	30	90	3	3	0	T, Z	E		3		S	Ob.

				1				K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
5	**ASB030753**	Advanced Steel-Concrete Composite Constructions (CE) Zaawansowane konstrukcje zespolone stalowo-betonowe	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W02, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W09, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
							2		30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
6	**ASB030853**	Advanced Soil Mechanics and Soil Structure Interaction (CE) Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W09, K2_W10, K2_W11, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
		Razem	13	1	6	1	3		360	900	30	30	7.8				30	8.8		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
13	1	6	1	3	360	900	30	30	7.8	8.8

Razem narastająco:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
29.8	11.67	11	11.67	4	1022	2700	90	90	38.6	31.6

Semestr 4

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB029954**	Master Thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Razem	0	0	0	0	0		0	900	30	30	7				30	30		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
0	0	0	0	0	0	900	30	30	7.0	30.0

Razem narastająco:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
29.8	11.67	11	11.67	4	1022	3600	120	120	45.6	61.6

Razem godzin ZZU: **1022**

Godziny - wykłady: **43.7%**

Godziny - pozostałe zajęcia: **56.3%**

ECTS - BU: **38.0%**

ECTS - P: **51.3%**

Specialization: Mechanics of Materials (MM)

Semestr 3

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB020553**	Laboratory Identification of Composite Microstructure Properties (CE) Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów	1					K2_W02, K2_W03, K2_W04, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W14, K2S_MM_W16, K2S_MM_U03, K2S_MM_U04, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	30	1	2	0.6	T, Z	Z		2		S	Ob.
					2				30	90	3	3	1	T, Z	Z		3	2	S	Ob.
							1		15	30	1			T, Z	Z				S	Ob.
2	**ASM003001**	Advanced Nano-Materials (ME) Zaawansowane nanomateriały	2					K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W17, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_U04, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3		T, Z	Z		3		S	Ob.
					2				30	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
						2			30	30	1	1	0.6				1	1	S	
3	**ASM003007**	Reliability and Maintenance Theory and Engineering (ME) Teoria i inżynieria niezawodności i eksploatacji	2					K2_W01, K2_W03, K2_W09, K2_W10, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W07, K2S_MM_W08, K2S_MM_W09, K2S_MM_U03, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.

5	**ASM003005**	Inventive Engineering (ME) Inżynieria wynalazczości	2					K2_W02, K2_W07, K2_W11, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W17, K2S_MM_U02, K2S_MM_U03, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	60	2	2		T, Z	Z		2		S	Ob.
						1			15	90	3	3	0.6	T, Z	Z		3	1	S	Ob.
6	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
		Razem	11	1	7	4	1		360	900	30	30	7.6				30	9.0		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
11	1	7	4	1	360	900	30	30	7.6	9.0

Razem narastająco:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
27.8	11.67	12	14.67	2	1022	2700	90	90	38.4	31.8

Semestr 4

Kursy obowiązkowe **liczba punktów ECTS 30**

L.p.		Nazwa kursu/grupy kursów (grupę kursów oznaczyć symbolem GK)	Tygodniowa liczba godzin					Symbol kierunkowego efektu uczenia się	Liczba godzin		Liczba pkt. ECTS			Forma[2] kursu/ grupy kursów	Sposób[3] zaliczenia	Kurs/grupa kursów				
			w	ć	l	p	s		ZZU	CNPS	łączna	zajęć DN[5]	zajęć BU[1]			ogólno-uczelniany[4]	zw. z dział. Nauk[5]	o char. praktycz. P[6]	rodzaj[7]	typ
1	**ASB029954**	Master Thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Razem	0	0	0	0	0		0	900	30	30	7				30	30		

Razem w semestrze:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
0	0	0	0	0	0	900	30	30	7.0	30.0

Razem narastająco:

Łączna liczba godzin					Łączna liczba godzin ZZU	Łączna liczba godzin CNPS	Łączna liczba punktów ECTS	Łączna liczba punktów ECTS zajęć DN[5]	Liczba punktów ECTS zajęć BU[1]	Liczba punktów ECTS zajęć P
w	ć	l	p	s						
27.8	11.67	12	14.67	2	1022	3600	120	120	45.4	61.8

Razem godzin ZZU: **1022**

Godziny - wykłady: **40.8%**

Godziny - pozostałe zajęcia: **59.2%**

ECTS - BU: **37.8%**

ECTS - P: **51.5%**

2. Zestaw egzaminów w układzie semestralnym

Lp.	Kod kursu	Nazwa kursów kończących się egzaminem	Semestr
1	ASB000152	Functional Analysis - Applications To Boundary Value Problems (CE)	2
2	ASM003002	Analytical Mechanics (ME)	2
3	ASM003004	Fracture Mechanics (ME)	3
4	ASB030753	Advanced Steel-Concrete Composite Constructions (CE)	3
5	ASB030853	Advanced Soil Mechanics and Soil Structure Interaction (CE)	3

3. Liczby dopuszczalnnego deficytu punktów ECTS po poszczególnych semestrach

Semestr	Dopuszczalny deficyt punktów ECTS po semestrze	Wymagana suma punktów do wpisu na kolejny semestr
1	15	15
2	13	47

Opinia właściwego organu Samorządu Studenckiego

Data Imię, nazwisko i podpis przedstawiciela studentów

Data Podpis Dziekana Wydziału / Dyrektora Filii

KATALOG KURSÓW

KARTY PRZEDMIOTÓW

WYDZIAŁ: Budownictwa Lądowego i Wodnego

KIERUNEK: **Advanced Solid Mechanics**

z obszaru nauk technicznych

POZIOM KSZTAŁCENIA: ~~I /~~ II * stopień, studia ~~licencjackie /~~ ~~inżynierskie /~~ magisterskie*

FORMA STUDIÓW: stacjonarna ~~/ niestacjonarna~~*

PROFIL: ogólnoakademicki ~~/ praktyczny~~ *

JĘZYK STUDIÓW: angielski

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Analiza funkcjonalna – zastosowania do problemów wartości brzegowych**
Nazwa przedmiotu w języku angielskim:	**Functional analysis – applications to boundary value problems**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	
Stopień studiów i forma:	**~~I~~ / II stopień*, stacjonarna / ~~niestacjonarna~~***
Rodzaj przedmiotu:	**obowiązkowy ~~/ wybieralny /~~ ~~ogólnouczelniany~~***
Kod przedmiotu:	**ASB000152**
Grupa kursów:	**~~TAK~~ / NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**	**30**			
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**	**60**			
Forma zaliczenia	**Egzamin /** ~~zaliczenie na ocenę~~*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**	**2**			
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)		**1**			
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**	**0.6**			

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Elementary course in calculus
2. Basic knowledge in ordinary differential equation

CELE PRZEDMIOTU

C1. Introducing elements of the theory of boundary value problems
C2. Familiarizing students with basing notions of functional analysis
C3. Demonstrating the mathematical basis of numerical solutions of boundary value problems

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
Z zakresu wiedzy: PEU_W01 Learn the basics of the theory of partial differential equations PEU_W02 Learn the contemporary methods of solving boundary problems PEU_W03 Learn the basics of functional analysis Z zakresu umiejętności: PEU_U01 Correctly distinguishes between types of differential equations and boundary problems PEU_U02 Knows the basics of distributive differentiation PEU_U03 Gains skills in formulating and solving numerically complex boundary problems PEU_U04 Is aware of the importance of the assumptions made PEU_U05 Knows the mathematical bases of the finite element method (FEM) and the boundary element method (BEM) PEU_U06 Is able to recognize the concept of metric spaces theory in various engineering problems. PEU_U07 Understands the weak formulation and variational formulation Z zakresu kompetencji społecznych: PEU_K01 Learns to think analytically, precisely formulate problems and solve them within a certain theory and with specific assumptions PEU_K02 Can work on solving problems in a team

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Wy1	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.	4
Wy2	The Laplace equation. Harmonic functions	2
Wy3	Metrix spaces: examples, convergence in metric spaces, complete metric spaces, the Banach fixed-point theorem.	2
Wy4	Normed spaces, Banach spaces, Linear operators and functionals, bounded operators (Banach's theorem).	4
Wy5	Unitary spaces and their geometrical properties (Pythagorean theorem), Hilbert spaces, orthogonal expansions, the orthogonal projection theorem. Continuous linear functionals in Hilbert spaces – the Riesz theorem.	6
Wy6	Sobolev spaces. Functions of compact support, distributions, distribution derivatives, properties of H1 and H2 spaces.	6
Wy7	Generalized solutions of elliptic equations. Weak formulation of boundary value problems, the Lax-Milgram theorem, applications of the Lax-Milgram theorem.	2
Wy8	Methods of solving of variational equations. The method of least squares, the orthogonal projection method, the Galerkin method, the Ritz method.	2
Wy9	Basis of finite element method	2
	Suma godzin	**30**

Forma zajęć - ćwiczenia		Liczba godzin
Cl1	Simplest methods of integrating partial differential equations.	1
Cl2	Reducing linear partial differential equation of the second order to canonical forms. Applications to solving boundary value problems.	4
Cl3	Solving boundary value problems by means variable separation method.	2
Cl4	Solving boundary value problems of the elliptic type.	2
Cl5	Solving problems dealing with distances in various metric spaces. Finding geometry of open and closed balls in various metric spaces.	2
Cl6	Applications of Banach's fixed point theorem.	2
Cl6	Solving problems dealing with normed and Banach spaces.	3
Cl7	Solving problem concerning bounded linear operators and bounded linear functionals.	2
Cl8	Problems on scalar product properties and geometry of unitary spaces.	3
Cl9	Approximation of various functions by using the orthogonal projection theorem.	2
Cl10	Solving problems on distributions and their derivatives.	3
Cl11	Applications of the Lax-Millgram theorem.	2
Cl12	Solving problems on applications of the Galerkin method and the Ritz method. Kolokwium zaliczające ćwiczenia (45 minut)	2
	Suma godzin	**30**

Forma zajęć - laboratorium		Liczba godzin
La1		

Forma zajęć - projekt		Liczba godzin
Pr1		

Forma zajęć - seminarium		Liczba godzin
Se1		

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1(lecture)	PEU_W01 PEU_W02 PEU_W03	Written exam
F2 (Classes)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_U05 PEU_U06 PEU_U07	Test
P = 0.7*F1 + 0.3*F2		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

LITERATURA PODSTAWOWA:

[1] R.V. Churchill, J.W.Brown, Fourier Series and Boundary Value Problems, McGraw-Hill Book Company, New York 1978.

[2] K. Yosida, Functional Analysis, Springer 1995.

[3] D. Farenick, Fundamentals fo Functional Analysis, Springer, 2016.

LITERATURA UZUPEŁNIAJĄCA:

[4] J.T. Odden and J.N. Reddy, An Introduction to Mathematical Theory of Finite Elements, J. Wiley & Sons, 1976.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

Prof. dr hab. inż. Wojciech Puła, W2/K09, Wojciech.pula@pwr.edu.pl

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Metody probabilistyczne w inżynierii**
Nazwa przedmiotu w języku angielskim: **Probabilistic methods in engineering**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASB000252**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**	**15**			**15**
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**	**30**			**30**
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**	**1**			**1**
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)		**1**			
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**	**0.6**			**0.6**

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. A basic course in calculus.
2. A basic course in mechanics.

CELE PRZEDMIOTU

C1. To familiarized students with most important probabilistic tools.
C2. To enable students to use probabilistic methods in their future work.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Learn about probability concept including modern approach based on measure theory. PEU_W02 Learn basics of random variables and random processes. PEU_W03 Learn to use statistical tools in conjunction with probability theory. PEU_W04 Learn to build probabilistic models for engineering use. relating to skills: PEU_U01 Is able to correctly understand basic notions within discrete and continuous probability theory PEU_U02 Knows evaluate probabilities and compute statistical moments of random variables PEU_U03 Is able to formulate simple statistical models regarding engineering problems PEU_U04 Is able to test various statistical various hypotheses PEU_U05 Can use reliability approaches in a design process relating to social competences: PEU_K01 Learn to work in a team PEU_K02 Is aware of the need to expand knowledge of modern techniques in engineering problems

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Number of hours**
Lec 1	Basic discrete probability theory.	1
Lec 2	Some basic concepts of probability based theory of measure.	2
Lec 3	Random variables, probability distributions, expected value, variance, moments of higher order. Random vectors, stochastic independence, covariance/correlation.	3
Lec 4	Common discrete and continuous distributions.	2
Lec 5	Multidimensional distributions.	2
Lec 6	Convergence of probability distributions. Limit theorems.	2
Lec 7	Random processes – basic facts.	3
Lec 8	Stationary random processes – correlation theory.	2
Lec 9	Probabilistic modelling of engineering problems – examples.	2
Lec 10	Estimation theory. Confidence intervals.	2
Lec 11	Testing of statistical hypothesis.	2
Lec 12	Bayesian approaches	2
Lec 13	Basic concept of decision theory.	2
Lec14	Structural reliability concepts.	3
	Total hours	**30**

Forma zajęć - ćwiczenia		**Liczba godzin**
Cl1	Solving simple problems on discrete probability.	1
Cl2	Solving problems on probability evaluations, computing statistical moments for both discrete and continuous case.	4
Cl3	Solving problems dealing with multivariate normal distributions.	2

Cl4	Applications of limit theorems.	2
Cl5	Solving problems on correlation structure of random processes.	2
Cl6	Simple modelling of engineering problems. Randomization.	2
Cl7	Carrying out of simple statistical tests.	2
	Total hours	**15**

Forma zajęć - laboratorium		**Liczba godzin**
Lab 2	**Not applicable**	
	Total hours	

Forma zajęć - projektu		**Liczba godzin**
Proj1	**Not applicable**	
	Total hours	

Forma zajęć - seminarium		**Liczba godzin**
Sem1	Probabilistic modeling of material properties.	2
Sem2	Probabilistic modelling of loads in civil engineering.	2
Sem3	Selected problems of stochastic dynamics.	4
Sem4	Kriging.	2
Sem5	Applications of reliability theory.	3
Sem6	Reliability based design.	2
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1(Lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04	Written exam
F2 (Classes)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_U05	Test
F5 (Seminar)	PEU_W04	Presentation
P = 0.6*F1 + 0.3*F2 + 0.1*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] FISZ M. (1980), *Probability theory and mathematical statistics*. Krieger Publ. Co.
[2] CHUNG K.L. (1974). *A course in Probability Theory.* Academic Press, New York.
[3] BENJAMIN J.R, CORNELL C.A. (2014). *Probability, Statistics, and Decision for Civil Engineers,* Dover Publications.

SECONDARY LITERATURE:

[1] FELLER W., *An Introduction to Probability Theory and its Applications,* vol.1 , vol. 2, J. Wiley and Sons.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

Prof. dr hab. inż. Wojciech Puła, W-2/K09, wojciech.pula@pwr.edu.pl

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Sztuczna inteligencja w inżynierii**
Nazwa przedmiotu w języku angielskim: **Artificial intelligence in engineering**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASB000352**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**		**30**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**		**60**		
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**		**2**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**2**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0,6**		**0,6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH
1. Basic knowledge in civil engineering – types of structures and processes
2. Skill in application of basic computer techniques

CELE PRZEDMIOTU
C1. Learning the fundamental techniques used in computer tools with elements of artificial intelligence – applied in civil engineering
C2. Development of ability to design, computer implementation and testing of simple expert tools with elements of artificial intelligence

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ	
Z zakresu wiedzy:	
PEU_W01	The student knows and understands methods of knowledge acquisition and representation in expert systems
PEU_W02	The student knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence
Z zakresu umiejętności:	
PEU_U01	The student has skill to independent acquisition of knowledge in civil engineering
PEU_U02	The student has skill to design, computer implementation and testing of simple expert tools with elements of artificial intelligence, supporting decisions in civil engineering
Z zakresu kompetencji społecznych:	
PEU_K01	The student is able to unaided solving the problems and is also prepared to a team-work (laboratory reports, laboratory exercises)

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Introduction to the lectures: aims, scope and plan of the course. Basic literature and examination rules.	2
Lec2	Artificial intelligence (AI) – what is this? Basic terms and definitions. Short history of development.	2
Lec3	Artificial intelligence in engineering and society. Artificial Intelligence Engineer. Main fields of applications. Examples.	2
Lec4	Artificial intelligence in expert systems – classification, architecture, evolution, directions of development. Expert systems and range of their application in engineering.	2
Lec5	Technologies of knowledge acquisition and representation in computer systems. Knowledge bases and data bases. Knowledge Engineer in knowledge acquisition process.	2
Lec6	Artificial neural networks (ANN) – inspiration and conception, development history. ANN architecture, training and testing techniques, validation criteria.	2
Lec7	Applications of artificial neural networks in engineering. Modelling, pattern recognition, classification, forecasting, estimation.	2
Lec8	Fuzzy logic – fuzzy problems, linguistic variables, fuzzy reasoning procedures, basic operators, testing and validation.	2
Lec9	Fuzzy logic – development history and examples of applications in engineering.	2
Lec10	Genetic algorithms – inspiration, conception, basic operators. Applications of evolutionary algorithms in optimization and search problems. Heuristic function and procedure.	2
Lec11	Expert and intelligent systems applied in engineering. Expert systems based on knowledge – design and implementation procedures.	2
Lec12	Technology of hybrid networks in intelligent systems – conception, components, design and creation procedures, testing and validation.	2
Lec13	Artificial intelligence applications in engineering – expert tools supporting structure analysis and infrastructure management.	2
Lec14	Future of AI. Artificial Intelligence and autonomous intelligent systems – directions of development. Opportunities and risks.	2
Lec15	Colloquium	2
	Suma godzin	**30**

Forma zajęć - ćwiczenia		Liczba godzin
Cl1		
...		
	Suma godzin	

Forma zajęć - laboratorium		Liczba godzin
Lab1	Introductory classes. Presentation of the rules for passing the course. Discussing the idea of example projects	2
Lab2	Introduction to artificial intelligence. Theoretical and practical foundations necessary to perform first exercise	2
Lab3	Presentation of the program for building neural networks and learning how to use it.	2
Lab4	Overview of the concept of the first exercise. Data collection	2
Lab5	Implementation of a neural network solving the given problem	2
Lab6	Checking, testing and evaluating the neural network No. 1. Discussion of the content of the first report .	2
Lab7	Overview of the concept of the second exercise. Theoretical foundations necessary to perform second exercise	2
Lab8	Development of a concept for solving the problem of exercise 2.	2
Lab9	Preparation of data and neural network architecture	2
Lab10	Implementation of a neural network solving the given problem	2
Lab11	Checking, testing and evaluating the neural network No. 2. Discussion of the content of the second report .	2
Lab12	Discussion of the concept of the third exercise. Theoretical foundations necessary to perform third exercise 3	2
Lab13	Development of a problem solution concept. Data collection and implementation of a neural network	2
Lab14	Checking, testing and evaluating the neural network No. 3. Overview of the content of the third report	2
Lab15	Completion of the course. Entering grades.	2
	Suma godzin	**30**

Forma zajęć - Project		Liczba godzin
Proj1		
…		
	Suma godzin	

Forma zajęć - Seminar		Liczba godzin
Sem1		
…		
	Suma godzin	

STOSOWANE NARZĘDZIA DYDAKTYCZNE
N1. Lecture: multimedia presentations of all parts of the course programme, presentation of computer software supporting bridge management. N2. Laboratory: multimedia presentations, software presentations, data preparation, data input and processing by means of computer systems, analysis and discussion of the results. N3. Individual consultations.

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
P (lecture)	PEU_W01, PEU_W02	Colloquium
P (laboratory)	PEU_U01, PEU_U02, PEU_K01	Final laboratory report, active work in laboratory

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

LITERATURA PODSTAWOWA:

[1] 1. Russell S., Norvig P., Artificial Intelligence: A Modern Approach, Prentice Hall, 2009.
[2] Samarasinghe S., Neural Networks for Applied Sciences and Engineering: From Fundamentals Complex Pattern Recognition, Auerbach Publications – Taylor & Francis Group, 2006.
[3] Wang P. P., Ruan D., Kerre E. E., Fuzzy Logic: A Spectrum of Theoretical and Practical Issues, Springer, 2007.

LITERATURA UZUPEŁNIAJĄCA:

[1] 1. Gurney K., An Introduction to Neural Networks, Taylor & Francis e-Library, 2005.
[2] Liebowitz J., The Handbook of Applied Expert Systems, CRC Press, 1999.
[3] Nguyen H. T., Prasad N. R., Walker C. L., Walker E. A., A First Course in Fuzzy and Neural Control, CHAPMAN & HALL/CRC, 2003.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

Department of Roads, Bridges, Railways and Airports
prof. dr hab. inż. Jan Bień, jan.bien@pwr.edu.pl
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Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Matematyczna homogenizacja i mikromechanika**
Nazwa przedmiotu w języku angielskim:	**Mathematical Homogenization and Micromechanics**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Stopień studiów i forma:	~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASB000453**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**		**30**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**		**60**		
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**		**2**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**1**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**		**0.6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Knowledge of the mechanics of a continuous medium.
2. Knowledge of the strength of materials.

CELE PRZEDMIOTU

C1. Acquire basic knowledge and skills in the field of multi-scale modeling.
C2. Developing skills in the field of composite media analysis.
C3. Expanding the knowledge of the mechanics of the continuous medium and the strength of

materials.
C4. To consolidate the ability to work on the entrusted task and awareness of the need to search for new theoretical and practical solutions.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Students know the basic assumptions of mathematical homogenization and micromechanics PEU_W02 Students know and understand the principles of analytical and computational approaches in the framework of micromechanics. relating to skills: PEU_U01 Students correctly formulate problems of mathematical homogenization and micromechanics and use analytical or computational approaches to solve them. PEU_U02 Students can use selected computer codes for solving various boundary value problems; they can correctly prepare data for calculations; they can interpret and critically evaluate results of analysis. relating to social competences: PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. . PEU_K02 Students are aware of the necessity of verifying the computational approach used and the correctness of the results obtained

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Introduction	2
Lec2	Principles of mathematical homogenization theory; H-convergence, two-scale convergence, Γ-convergence	2
Lec3	Method of asymptotic developments: linear elasticity problem, heat flow problem	2
Lec4	Evaluation of effective properties of composite with periodic microstructure. Numerical implementation of periodic boundary conditions	2
Lec5	Principles of micromechanics. Direct and inverse problems. Simmulated annealing approach.	2
Lec6	Computational and analytical methods	2
Lec7	Analytical methods: Eshelby solution of single inclusion problem, bounds on effective properties	2
Lec8	Analytical methods: Maxwell approximation scheme, Mori-Tanaka approximation scheme	2
Lec9	Analytical methods: Self-Consistent approximation scheme, Differential Effective Medium approach	2
Lec10	Analytical methods: concentration parameter, average shape, equivalent microstructure approach	2
Lec 11	Computational micromechanics: statistical microstructure descriptors, notion of Representative Volume Element (RVE), minimum size of RVE	2
Lec 12	Computational micromechanics: Principles of Monte Carlo simulations, sufficient number of realizations (Central Limit Theorem, Chebyshev's Inequality)	2
Lec13	Computational micromechanics: numerical methods – Finite Volume Method, Finite Element Method	2

Lec14	Estimation of effective properties based on digital image of microstructure: linear elasticity and heat flow problems	2
Lec15	Examples of applications of micromechanics to engeeniring problems	2
	Total hours	**30**

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Introduction. Discussion of the laboratory content and presentation of the rules for passing the course	2
Lab2	Computational micromechanics. Solving simple computational examples for determining the effective parameters of periodic microstructures – transport problems	2
Lab3	Computational micromechanics. Solving simple computational examples for determining the effective parameters of periodic microstructures – linear elasticity problems	2
Lab4	Computational micormechanics. Solving simple computational examples for determining the effective parameters of random microstructures – transport problems	2
Lab5	Computational micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – linear elasticity problems	2
Lab6	Analytical micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – transport problems.	2
Lab7	Analytical micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – linear elasticity problems.	2
Lab9	Determination of statistical microstructure descriptors.	2
Lab10	Determination of statistical microstructure descriptors.	2
Lab11	Solving simple inverse problems of micormechanics: determination of concentration parameter.	2
Lab12	Solving inverse problems of micormechanics: reconstruction of microstructure geometry.	2
Lab13	Solving inverse problems of micormechanics: reconstruction of microstructure geometry.	2
Lab14		2
Lab15	Completion of the course. Presentation of students' reports.	2
	Total hours	**30**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się

F1 (lecture) F2 (laboratory)	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K01 PEU_K02	Written exam Final report note
P=0.6*F1+0.4*F2		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] Milton G. W.: The Theory of Composites, Cambridge Univ. Press, 2002.
[2] Torquato S.: Random heterogeneous materials, Springer, 2000.
[3] Hornung U.: Homogenization and porous media, Springer, 1997.
[4] Łydżba D.: Effective properties of composites, Wrocław, 2011.

SECONDARY LITERATURE:

[1] Cherkaev A.: Variational methods for structural optimization, Springer, 2000.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

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Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów**
Nazwa przedmiotu w języku angielskim: **Laboratory identification of composite microstructure properties**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy): **Mechanics of Materials (MM)**
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASB020553**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**15**		**30**		**15**
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**30**		**90**		**30**
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**1**		**3**		**1**
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**2**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**		**1**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Knowledge of the mechanics of a continuous medium.
2. Knowledge of the strength of materials.

CELE PRZEDMIOTU

C1. Acquire basic knowledge and skills in the field of laboratory tests of microstructures.
C2. Developing skills in the field of composite media analysis.

C3. Expanding the knowledge of the mechanics of the continuous medium and the strength of materials.
C4. To consolidate the ability to work on the entrusted task and awareness of the need to search for new theoretical and practical solutions.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Students know advanced microstructural laboratory techniques. PEU_W02 Students know and understand the assumptions and principles of laboratory identification of geometrical and mechanical morphology of microstructure. relating to skills: PEU_U01 Students are able to correctly prepare a sample and conduct a test using advanced techniques for determining the geometrical and mechanical morphology of micro-heterogeneous materials. PEU_U02 Students are able to interpret the results as well as perform further extended analyzes using the data obtained from the study relating to social competences: PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. PEU_K02 Students are aware of the need to verify the applied methodology and the correctness of the obtained research results.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Number of hours**
Lec1	Introduction	1
Lec2	Physical and mathematical foundations of X-Ray computed tomography: Radon transform, Reconstruction procedure (Feldkamp algorithm).	2
Lec3	Statistical descriptors of digital representation of microstructure: volume porosity, fraction of open and closed pores, pore size distribution, pore shape distribution, tortuosity.	2
Lec4	Principles of nanoindentaion tests: Sneddon's solution, loading paths, evaluation of indentation depth, area of imprint.	2
Lec5	Grid Indentation Technique: histograms, segmentation, complex load paths, scales of observation, scale effect.	2
Lec6	Practical applications of nanoindentation technique.	2
Lec7	Principles of Scanning Electron Microscopy (SEM), evaluation of surface morphology descriptors.	2
Lec8	Practical applications of combined use of nanoindentation, X-Ray mCT and SEM. Completion of the course by students.	2
	Total hours	**15**

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Introduction.	2
Lab2	Presentation and discussion of equipment for laboratory tests: X-Ray mCT	2
Lab3	Presentation and discussion of equipment for laboratory tests:	2

	Nanoindentation	
Lab4	Presentation and discussion of equipment for laboratory tests: SEM	2
Lab5	Preparation of samples for testing	2
Lab6	Imaging of microstructure of microheterogeneous materials with X-Ray mCT	2
Lab7	Reconstruction of microstructure from acuired plane images	2
Lab8	Determination of mechanical morphology of microheterogeneous materials: nanoindentation tests	2
Lab9	Determination of mechanical morphology of microheterogeneous materials: nanoindentation tests	2
Lab10	Numerical analysis of nanoindentation results. Deconvolution	2
Lab11	Determination of surface morphology by SEM	2
Lab12	Determination of surface morphology by SEM	2
Lab13	Students' own work: preparation of reports	2
Lab14	Students' own work: preparation of reports	2
Lab15	Students' own work: preparation of reports	2
	Total hours	**30**

Forma zajęć - Seminar		**Liczba godzin**
Sem1	Introduction	1
Sem2	Students' presentations	2
Sem3	Students' presentations	2
Sem4	Students' presentations	2
Sem5	Students' presentations	2
Sem6	Students' presentations	2
Sem7	Students' presentations	2
Sem8	Students' presentations	2
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE
N1. multimedia presentation N2. personal computer, interactive whiteboard (calculations, drawings, descriptions) N3. laboratory equipment

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Test
F2 (seminar)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Presentation
F3 (laboratory)	PEU_U01 PEU_U02	Final Report note

	PEU_K01 PEU_K02	
P=0.3*F1+0.3*F2+0.4*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
PRIMARY LITERATURE:
[1] Milton G. W.: The Theory of Composites, Cambridge Univ. Press, 2002.
[2] Torquato S.: Random heterogeneous materials, Springer, 2000.
[3] Stock, S. R. (2019). Microcomputed tomography: methodology and applications. CRC press.
[4] Fischer-Cripps, A. C. (2009). Handbook of nanoindentation. Fischer-Cripps Laboratories Pty Ltd, Forestville, Australia.
[5] Goldstein, J. I., Newbury, D. E., Michael, J. R., Ritchie, N. W., Scott, J. H. J., & Joy, D. C. (2017). Scanning electron microscopy and X-ray microanalysis. Springer.
SECONDARY LITERATURE:
[1] Scrivener, K., Snellings, R., & Lothenbach, B. (Eds.). (2018). A practical guide to microstructural analysis of cementitious materials. Crc Press.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)
Prof. Dariusz Łydżba, Dariusz.Lydzba@pwr.edu.pl Faculty of Civil Engineering, Wroclaw University of Science and Technology

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Praca dyplomowa**
Nazwa przedmiotu w języku angielskim:	**Master (MSc) thesis**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Stopień studiów i forma:	**~~I~~ / II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASB029954**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)					
Liczba godzin całkowitego nakładu pracy studenta (CNPS)				**900**	
Forma zaliczenia	Examination / crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS				**30**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**30**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)				**7,0**	

* delete as appropriate

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Has an advanced theoretical knowledge and skills in accordance with the requirements of the field of study *Advanced Solid Mechanics* of the second cycle of the program, including Mechanics of Structure (MS) / Mechanics of Materials (MM) specialty.
2. Can shape, model, analyze, and measure complex structural components.
3. Knows the applicable standards, guidelines and regulations for the design of buildings, including the extended in the range of structures.
4. Has the ability and computational efficiency in design, including computer-aided calculation and plotting.
5. Has the ability to independently acquire, use, and analysis of scientific and technical information.

CELE PRZEDMIOTU
C1. Synthesis of knowledge of the whole the second cycle studies and practical experience, especially in the chosen diploma specialty. C2. Getting knowledge of the planning and realization of a variety, complex technical, scientific and technical research. C3. Strengthening the knowledge of the principles of programming, modeling and solving complex engineering design tasks. C4. Learning students how to select and use advanced computational tools, including computer programs. C5. Strengthening skills of development the results and drawing conclusions. C6. Strengthening the ability to use and critical analysis of scientific and technical information.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ	
Z zakresu wiedzy:	
PEU_W01	Has a well-established and extended knowledge of the issues of the construction industry, mechanics, particularly in the area of diploma specialization.
PEU_W02	Has a theoretically grounded knowledge of programming, modeling and solving complex design engineering tasks.
PEU_W03	Knows the rules for the application of advanced techniques and computer programs supporting the design and research processes.
Z zakresu umiejętności:	
PEU_U01	Has detailed, developed skills in solving problems in the construction industry, mechanics in particular of the studying specialty.
PEU_U02	Has the ability to collect and critically analyze, from a variety of sources, of information in the field of construction, mechanics especially of the studying specialty.
PEU_U03	Can select the methods and tools to solve complex engineering tasks and basic research problems.
PEU_U04	Has the ability to document the work or research projects done by himself and their presentation.
PEU_U05	Is able to establish directions of further education and follow the process of self learning.
Z zakresu kompetencji społecznych:	
PEU_K01	Is able to set priorities for implementation of specified by himself or the others tasks or research projects and is responsible for his decisions.
PEU_K02	Has an internal belief in the need for the continuous self-development, including related to his profession.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1		
…		
	Total hours	

Forma zajęć - ćwiczenia		**Liczba godzin**
Cl1		
...		
	Total hours	

Forma zajęć - laboratorium		Liczba godzin
Lab1		
…		
	Total hours	

Forma zajęć - projekt		Liczba godzin
Proj1		
…		
	Total hours	

Forma zajęć - seminarium		Liczba godzin
Sem1		
…		
	Total hours	

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	Studies of literature and other sources of information.
N2.	Preparation and execution of calculations and / or experimental and / or case study analysis.
N3.	Analysis of the comparisons results, summary, formulation of conclusions, editorial preparation of the thesis.
N4.	Participation in consultations related to the thesis, summarizing discussions.

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
P1, P2, P3, P4	PEU_W01, PEU_W02, PEU_W03, PEU_U01, PEU_U02, PEU_U03, PEU_U04, PEU_U05, PEU_K01, PEU_K02	Rating the thesis by the supervisor and reviewer. Thesis defense. Diploma exam.
P1 – evaluation of the thesis by the supervisor and reviewer P2 – defense of the thesis P3 – evaluation of diploma exam		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
Literature depending on specialty in which the diploma is realized. Literature related to the thesis topic chosen independently by student and under the direction of the supervisor.
OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)
Thesis supervisor.

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Ocena ryzyka w geotechnice – zastosowania teorii pól losowych**
Nazwa przedmiotu w języku angielskim:	**Risk assessment in geotechnics - implementation of Random Field Theory**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Structure (MS)**
Stopień studiów i forma:	~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASB030553**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**45**		**15**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**		**60**		
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**		**2**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**1.2**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**		**0.6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Basic course in geotechnical engineering or basic course in soil mechanics
2. Basic course in statistics and probability
3. Calculus – engineering level

CELE PRZEDMIOTU

C1. To enable students to recognise sources of uncertainty in geotechnics
C2. To enable students to use probabilistic methods in their future work
C3. To enable students to use selected computer tools for risk analysis in geoengineering
C4. To teach students the basis of reliability based design in geoengineering

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Learn about probability distributions used for describing geotechnical parameters PEU_W02 Learn basics of random filed generation PEU_W03 Knows the parameters characterized random fields (scale of fluctuation, correlation matrix, autocorrelation function) PEU_W04 Learn the basics of stochastic finite element method relating to skills: PEU_U01 Is able to applied the random fields for soil spatial variability characterization PEU_U02 Knows the kriging technique and is able to use some kriging's software PEU_U03 Is able to operate software dedicated to reliability assessments available in the spreadsheets form PEU_U04 Is able to applicate stochastic finite element method to engineering problems PEU_U05 Can use reliability approaches in a design process relating to social competences: PEU_K01 Learn to work in a team PEU_K02 Is aware of the need to expand knowledge of modern techniques in geotechnical engineering

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec 1	General comments on uncertainty in geotechnical analyses. Sources and types of uncertainty in geomechanical properties.	1
Lec 2	Stochastic processes and random fields – basic theory.	6
Lec 3	Common random fields models.	3
Lec 4	Probabilistic modelling of geomechanical properties. Spatial averaging.	4
Lec 5	Linear regression. Best linear unbiased estimation. Geostatistics-Kriging.	4
Lec 6	Basic of simulation techniques.	4
Lec 7	Simulation of random fields.	2
Lec 8	Reliability assessments in geotechnics with examples.	3
Lec 9	Applications in bearing capacity problems.	2
Lec 10	The Random Finite Element Method (RFEM). An overview.	4
Lec 11	RFEM applications to 2-D seepage problems and earthdam modelling.	2

Lec 12	RFEM application to shallow foundation settlement.	2
Lec 13	RFEM applications to earth pressure problem and slope stability analysis.	2
Lecture 14	Reliability based design.	6
	Total hours	**45**

Forma zajęć - ćwiczenia		**Liczba godzin**
Cl1	**Not applicable**	
	Total hours	

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Reliability measures evaluation using FORM/SORM methods, by means of dedicated software	7
Lab 2	Risk analysis of bearing capacity of foundation by FREM – numerical evaluations	8
	Total hours	**15**

Forma zajęć - projekt		**Liczba godzin**
Proj1	**Not applicable**	
	Total hours	

Forma zajęć - seminarium		**Liczba godzin**
Sem1	**Not applicable**	
	Total hours	

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1	PEU_W01 PEU_W02 PEU_W03	Oral exam
F2		
F3	PEU_U03 PEU_U04	
P=0.7*F1+0.3*F2		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
LITERATURA PODSTAWOWA:
[1] FENTON G.A., GRIFFITHS D.V. (2008), *Risk assessment in geotechnical engineering*. John

Wiley & Sons, Hoboken, N.J.
[2] BAECHER G.B., CHRISTIAN J.T. (2003), *Reliability and Statistics in Geotechnical Engineering*. J. Wiley & Sons, Chichester.
[3] FISZ M. (1980), *Probability theory and mathematical statistics*. Krieger Publ. Co.

LITERATURA UZUPEŁNIAJĄCA:

[1] Probabilistic methods in geotechnical engineering. Ed. by D. V. Griffiths, Gordon A. Fenton. Wien; New York: **Springer**, cop. 2007. s. 127-145. ISBN: 978-3-211-73365-3.
[2] *Eurocode 7 and reliability-based design*. In: *Reliability Based Design in Geotechnical Engineering*, Taylor and Francis, London–New York.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

Prof. dr hab. inż. Wojciech Puła, W-2/K09, wojciech.pula@pwr.edu.pl

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Zaawansowana Geoinżynieria**
Nazwa przedmiotu w języku angielskim: **Advanced Geoenginnering**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy): **Mechanics of Structure (MS)**
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASB030653**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**			**15**	**15**
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**30**			**60**	**60**
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	~~Egzamin /~~ **zaliczenie na ocenę***
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**1**			**2**	**2**
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**1**	**1.2**
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**			**0.6**	**0.6**

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Fundamentals of bearing constructions in civil engineering, fundamentals of strength of materials and soil mechanics.
2. Basic types of foundations for different simple geoengineering conditions, geotechnical categories GC1 and GC2, construction processes of foundations, functional and environmental aspects of foundations depending on the type of object, loadings, soil conditions and water in soils.
3. Principles of soil-structure interacion for undeformable foundations, piles, embedded walls, retaining structures; calculation of the bearing capacity, stability of slopes, calculation of soil and water pressure.
4. Design of basic concrete elements, like beams, footings and columns; reinforcement calculation.
5. Solving of the simplest linear ordinary differential equations with constant coefficients.

CELE PRZEDMIOTU

C1. Knowledge of wide range of methods for strengthening the soil for creating better contact conditions.
C2. Developing knowledge through a spectrum of foundation methods, from direct foundation through soil reinforcement methods to indirect geotechnical structures.
C3. Ability in modelling of the soil-structure interaction
C4. Building an engineering intuition in prediction of internal forces in foundations and rational analysis of structures interacting with the subsoil.
C5. Gaining knowledge in more complex problems of producing energy from geotechnical renewable sources.
C6. Developing skills in design of foundation under spatial facilities as wind turbines, energy piles or energy tunnels.
C7. Understanding the backgrounds of design approaches with partial safety factors due to the Eurocode 7.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

Z zakresu wiedzy:
PEU_W01 Student gains a theoretical knowledge in calculation of foundation beams, as well as piles and walls embedded in soils, a better understanding of the method of strengthening the soil,
PEU_W02 understands a theoretical background of the method of partial safety factors in geoengineering, uses the design approaches required by the Eurocode EC7-1 – the GEO stability criteria in this group,
PEU_W03 understands problems of soil-structure interaction on the example of poor-loading subsoils, knows how to design pile constructions transmitting large loadings on the soil and produce energy

Z zakresu umiejętności:
PEU_U01 Student can define and apply appropriate calculation models for foundations and soils, analyses internal forces in foundations and combinations of such actions (also for mining excitations),
PEU_U02 can select the appropriate technology based on material characteristics and soil and water conditions,
PEU_U03 can interpret and use in design knowledge resulting from the results of geotechnical studies
PEU_U04 becomes skillful in modelling of the soil-structure interaction problems, can calculate more complex foundations within the geotechnical category 2 and 3,

Z zakresu kompetencji społecznych:
PEU_K01 student improves the ability to work alone and in a group of designers (due to discussions with other students during class-projects and with the teacher),
PEU_K02 drills in logical thinking, clear formulation of theses and requirements, concentration on given tasks – within a given theory and set margins of assumptions.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Introduction. Preliminary information. Basic definitions.	2
Lec 2	Soil investigation methods	2
Lec3-4	Types of contact surfaces between the structure and the soil. The types of direct foundation methods	4
Lec5-7	Geotechnical conditions for the application of soil strengthening techniques. The spectrum of soil strengthening methods and the indirect foundation methods.	6
Lec8-9	Protection of deep excavations walls: types and applied technologies.	4
Lec10	The foundation of special facilities such as, i.e., wind turbines, energy piles, or briges.	2
Lec11-13	Application of geotechnical technologies to the process of producing energy from renewable sources.	6
Lec14	Impact of vibration caused by geotechnical works on various types of objects.	2
Lec15	Final test	2
	Suma godzin	**30**

Forma zajęć - projekt		**Liczba godzin**
Pr1	Introduction	1
Pr2-4	Soil strengthening project	6
Pr5-7	Energy geostructure project	6
Pr8	Evaluation of reports – final report note evaluation	2
	Suma godzin	**15**

Forma zajęć - seminarium		**Liczba godzin**
Sem1	Introduction	1
Sem2-8	Students' presentations	14
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1 (lecture)	PEU_W01, PEU_W02 PEU_W03	Fimal Test
F2 (project)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_K01 PEU_K02	Final Report note
F3 (seminar)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_K01 PEU_K02	Oral presentation and raport
P=0.4*F1+0.3*F2+0.3*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

LITERATURA PODSTAWOWA:

[1] Salgado, R. (2008). *The engineering of foundations* (Vol. 888). New York: McGraw Hill.

[2] Budhu, M. (2008). *Foundations and earth retaining structures*. John Wiley & Sons Incorporated..

[3] Eslami, A., Moshfeghi, S., Molaabasi, H., & Eslami, M. M. (2019). *Piezocone and Cone Penetration Test (CPTu and CPT) Applications in Foundation Engineering*. Butterworth-Heinemann.

[4] Laloui, L., & Di Donna, A. (2013). Energy geostructures. *ISTE and John Wiley & Sons*.

[5] Laloui, L., & Loria, A. F. R. (2019). *Analysis and design of energy geostructures: theoretical essentials and practical application*. Academic Press.

LITERATURA UZUPEŁNIAJĄCA:

[1] Keller promotional materials

[2] A. Jarominiak, Lekkie konstrukcje oporowe, WKŁ, W-wa, 1999

[3] EN 1997-1:2004

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

PHD. DSC. JOANNA PIECZYŃSKA-KOZŁOWSKA,
joanna.pieczynska-kozlowska@pwr.edu.pl
Faculty of Civil Engineering, Wroclaw University of Science and Technology

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Zaawansowane konstrukcje zespolone stalowo-betonowe**
Nazwa przedmiotu w języku angielskim: **Advanced steel-concrete composite constructions**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy): **Mechanics of Structure (MS)**
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASB030753**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**				**30**
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**				**60**
Forma zaliczenia	**Egzamin /** ~~zaliczenie na ocenę~~*	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**				**2**
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)					**1.2**
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**				**0.6**

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH
1. Advanced knowledge of the mechanics of construction and civil engineering 2. Knowledge of the steel and concrete structures. 3. Basic knowledge of the steel-concrete composite constructions. 4. Knowledge of the FEM

CELE PRZEDMIOTU
C1. Familiarization with contemporary steel-concrete composite structures.

C2. Familiarization with advanced methods of laboratory tests of steel-concrete composite structures.
C3. Familiarization with advanced methods of numerical simulation of behavior of steel-concrete composite structures.
C4. Familiarization with shear connection using composite dowels.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 The student knows and understands solutions used in modern steel-concrete composite structures. PEU_W02 The student knows methodology of design and laboratory testing. relating to skills: PEU_U01 Has the skill to build a global computational model of composite structure. PEU_U02 Has the skill to build a local model of composite node and connection. relating to social competences: PEU_K01 The student is prepared to a team-work.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Subject and scope of the lecture, literature, rules of getting credit. State-of-the art of classic steel-concrete composite structures. Introduction to general composite section.	2
Lec2	Introduction to The History of the Theory of Structures. Working with old structures: strengthening and external prestressing of composite structures.	2
Lec3	Composite structures in buildings and bridges: main differences. Bridge construction – a strong driving force for developments in composite construction.	2
Lec4	Evolution of composite bridges. Basis of design of composite bridges. Un-cracked analysis and cracked analysis.	2
Lec5	From welded studs to composite dowels: evolution of shear connection. Fundamentals of Eurocode 4: steel skeleton.	2
Lec6	Evolution of composite dowels: from VFT to VFT-WIB.	2
Lec7	Composite dowels: searching for the shape and construction of first bridges. The first generation of bridges using composite dowels.	2
Lec8	Composite dowels: searching for design procedures and technology of production of steel part.	2
Lec9	Composite dowels: the final solution. Formal design procedures. The second generation of bridges using composite dowels.	2
Lec10	The concept of general composite section. The third generation of bridges using composite dowels. The forms constructed nowadays and predictable future.	2
Lec11	Laboratory testing of composite constructions: tests under static loads.	2
Lec12	Laboratory testing of composite constructions: tests under cyclic loads.	2
Lec13	FEM for purposes of laboratory testing:.	2
Lec14	FEM for purposes of design. Development of EC4.	2
Lec15	Colloquium	2
	Total hours	**30**

Forma zajęć - seminarium		Liczba godzin
Sem1	General introduction: organization, crediting rules. Distribution of individual tasks, discussion of each task.	1
Sem2	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem3	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem4	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem5	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem6	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem7	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem8	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem9	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem10	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem11	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem12	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem13	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem14	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem15	Evaluation of the seminar.	2
	Total hours	**30**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
E Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
P (lecture)	PEU_W01, PEU_W02	Colloquium
F (seminar)	PEU_U01, PEU_U02, PEU_K01	Active work during seminar.

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] [1Kurrer K-E. The History of the Theory of Structures: Searching for Equilibrium. Ernst & Sohn 2018.

[2] Lorenc, W. Composite dowels: the way to the new forms of steel-concrete composite structures. IABSE Symposium 20-22.05.2020, Poland.

[3] Jacques Berthellemy, Günter Seidl, Wojciech Lorenc Recent structures and bridges built with the CL steel-concrete connection. W: Tomorrow's Megastructures : 40th IABSE Symposium 2018, Nantes, France, 19-21 September 2018. Zurich : IABSE, 2018. art. S2-51, s. 1-9.

[4] Dennis Rademacher, Wojciech Ochojski, Wojciech Lorenc, Maciej P. Kożuch Advanced solutions with hot-rolled sections for economical and durable bridges. Steel Construction. 2018, vol. 11, nr 3, s. 196-204.

[5] Wojciech Lorenc Nośność ciągłych łączników otwartych w zespolonych konstrukcjach stalowo-betonowych. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej, 2010. 131, [2] s.

[6] Wojciech Lorenc The model for a general composite section resulting from the introduction of composite dowels. Steel Construction. 2017, vol. 10, nr 2, s. 154-167.

[7] Wojciech Lorenc Non-linear behaviour of steel dowels in shear connections with composite dowels: design models and approach using finite elements. Steel Construction. 2016, vol. 9, nr 2, s. 98-106.

[8] Wojciech Lorenc The design concept for the steel part of a composite dowel shear connection. Steel Construction. 2016, vol. 9, nr 2, s. 89-97.

SECONDARY LITERATURE:

[9] Wojciech Lorenc. Nowe technologie budowy mostów zespolonych. W: Mosty hybrydowe : Seminarium Naukowo-Techniczne Wrocławskie Dni Mostowe, Wrocław, 29-30 listopada 2018 / [red. Jan Biliszczuk, Jerzy Onysyk]. Wrocław : Dolnośląskie Wydawnictwo Edukacyjne, [2018]. s. 101-118.

[10] Günter Seidl, Wojciech Lorenc Innovative Konstruktionen im Verbundbrückenbau mit Verbunddübelleisten. Stahlbau. 2018, Jg. 87, H. 6, s. 547-554.

[11] Wojciech Lorenc, Tomasz Kołakowski, Andrzej Hukowicz, Günter Seidl Verbundbrücke bei Elbląg : Weiterentwicklung der VFT-WIB-Bauweise. Stahlbau. 2017, Jg. 86, H. 2, s. 167-174.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

Wojciech Lorenc Wojciech.Lorenc@pwr.edu.pl
Faculty of Civil Engineering, Wroclaw University of Science and Technology

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem**
Nazwa przedmiotu w języku angielskim:	**Advanced Soil Mechanics and Soil – Structure Interaction**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Structure (MS)**
Stopień studiów i forma:	~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASB030853**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**		**30**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**		**60**		
Forma zaliczenia	**Egzamin /** ~~zaliczenie na ocenę~~*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**		**2**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**1.2**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**		**0.6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH
1. Knowledge in Mechanics, Strength of Materials, and general principles of design of Civil Engineering Structures 2. Basic knowlege of geology

CELE PRZEDMIOTU
C1. To learn the methods of computing stress and deformation of soil substrate taking the specifics of

soil medium into account.
C2. To get the knowledge of theoretical description of water flow in soil medium.
C3. To learn the basics of hydro-mechanical coupling and its implications to practical problems.
C4. To learn the basics of soil plasticity, theory of limit states, methods for determining the bearing capacity of foundations and analyzing the stability of slopes.
C5. To acquire the ability to correctly formulate computational models of typical problems in geotechnics, solve them and interpret the results obtained.
C6. To learn the basics of modelling the interaction between the engineering structures and soil substrate.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

relating to knowledge:
PEU_W01 Students know the basic assumptions and constitutive laws used in soil mechanics.
PEU_W02 Students know and understand the principles of computer-aided modelling and calculation of geotechnical structures

relating to skills:
PEU_U01 Students correctly formulate problems concerning the interaction of the structure with the subsoil and use computer codes to solve them.
PEU_U02 Students can use selected computer codes supporting modelling of geoengineering structures; they can correctly prepare data for calculations; they can interpret and critically evaluate results of numerical analysis.

relating to social competences:
PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. .
PEU_K02 Students are aware of the necessity of verifying the computational approach used and the correctness of the results obtained.

TREŚCI PROGRAMOWE

Forma zajęć - wykład		**Liczba godzin**
Lec1	Formation and classification of soils	2
Lec2	Basic relations in the theory of elasticity. Uniaxial strain and plane strain states. Analytical solutions for uniform soil half-space.	2
Lec3	Settlements in uniaxial strain state. Virgin compression and unloading/reloading lines. Compression and recompression indices.	2
Lec4	In situ stresses in soils. Concept of effective stress.	2
Lec5	Darcy Law. General equation of water flow in soil. Soil-water characteristic curve.	2
Lec6	One dimentional consolidation. Hydromechanical coupling.	2
Lec7	Mohr-Coulomb strength criterion. Mohr circles. Active and passive earth pressures.	2
Lec8	Limit states theorems. Lower and upper bound of critical load for strip foundation. Finite element limit analysis.	2
Lec9	Platicity theory in the view of numerical methods.	2
Lec10	Slope stability. Angle of natural slope. Kinemtic method. Examples.	2
Lec 11	Fellenius and Bishop methods. Shear strength reduction technique. Examples.	2
Lec 12	Models of soil-structure contact zone in the view of numerical methods. Stifness of contact.	2

Lec13	Examples of numercial computations in practical geotechnical problems.	2
Lec14	Examples of numercial computations in practical geotechnical problems - continuation.	2
Lec15	Examples of numercial computations in practical geotechnical problems - continuation. Lecture summary.	2
	Total hours	**30**

Forma zajęć - laboratorium		Liczba godzin
Lab1	Modelling of soil subsrate. Variability of layers' thickness. Spatial variability of parameters.	2
Lab2	Elasticity. Formulartion of boundary-value problem.	2
Lab3	Solving geotechnical problems using elastic model.	2
Lab4	Solving geotechnical problems using the concept of effective stress.	2
Lab5	Solving of individualy assigned problems by students and preparation of a report No. I	2
Lab6	Water flow in soil. Formulation of initial boundary-value problem.	2
Lab7	Modelling of problems with changing phreatic surface.	2
Lab8	Problem of consolidation.	2
Lab9	Solving of individualy assigned problems by students and preparation of a report No. II	2
Lab10	Assesment of slope stability using limit equlibrum methods.	2
Lab11	Assesment of slope stability using sher strength reduction technique. Discussion of diffrences in results between the methods.	2
Lab12	Solving of individualy assigned problems by students and preparation of a report No. III	2
Lab13	Modelling of soil embedded structures considering soil-structure interaction.	2
Lab14	Modelling of soil embedded structures considering soil-structure interaction, continuation.	2
Lab15	Solving of individualy assigned problems by students and preparation of a report No. IV	2
	Total hours	**30**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1 (lecture)	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K02	Written exam
F1 (laboratory)	PEU_U01	Reports

	PEU_U02 PEU_K01 PEU_K02	
P=0.6*F1+0.4*F2		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
PRIMARY LITERATURE: [1] Verruijt, A. (2001). Soil mechanics. Delft: Delft University of Technology. [2] Das, B.M. (2019). Advanced soil mechanics. CRC Press. 5th Ed. [3] Derski,W, Izbicki, R., Kisiel, I., Mróz, Z. (1988). Rock and soil mechanics. PWN/Elsevier [4] Commend, S., Kivell, S., Obrzud, R.F., Podleś, K., Truty, A., & Zimmermann, T. (2018). Computational geomechanics. Getting started with ZSOIL. PC. Rossolis Editions. V Ed. **SECONDARY LITERATURE:** [1] EN 1997-1 Eurocode 7: Geotechnical Design - General Rules [2] Fredlund, D.G, Rahardjo, H., Fredlund, M.D. (2012). Unsaturated Soil Mechanics in Engineering Practice. Wiley [3] de Vallejo, L.G., Ferrer, M. (2011). Geological engineering. CRC Press/Balkema. [4] FlexPDE User Manual [5] Itasca Flac User Manual [6] ZSoil User Manual

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)
DR INŻ. MAREK KAWA **DR INŻ. MACIEJ SOBÓTKA** Department of Geotechnology, Hydro Technology, and Underground and Hydro Engineering, Faculty of Civil Engineering, Wroclaw University of Science and Technology

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Zaawansowane nanomateriały**
Nazwa przedmiotu w języku angielskim: **Advanced Nano-materials**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASM003001**
Grupa kursów: ~~TAK~~ **/ NIE****

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**		**30**	**30**	
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**		**30**	**30**	
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**		**1**	**1**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)			**1**	**1**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)			**0.6**	**0.6**	

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Knowledge of Mechanics and Materials Science.
2. Knowledge of chemistry and physics at least at the advanced level of high school
3. Knowledge of basic experimental mechanics

CELE PRZEDMIOTU

C1. To learn the production of amorphous and nanocrystalline alloys by different rapid quenching methods
C2. Knowledge of experimental methods for determining the crystallization kinetics of amorphous metallic materials

C3. Learn to analize mechanical and magnetic properties of amorphous and nanocrystalline metallic alloys
C4. Learn to analyze the influence of chosen structural parameters on nanomaterials application
C5. Be able to indicate the form of the material for a specific application
C6. Acquiring skills of scientific cooperation in a team obtaining and analyzing different form of sol-gel materials.
C7. Acquisition of basic knowledge in the development of scientific expertises

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Has extensive knowledge of operation of measurements systems. relating to skills: PEU_U01 Is able to use different methods of materials properties measurements (e.g. wettability, spectroscopy, electrochemistry, mechanical) PEU_U02 Is able to analyse results of chosen measurements of nanomaterials properties (e.g. wettability, spectroscopy, electrochemistry, mechanical) relating to social competences: PEU_K01 Can think and act in a creative and entrepreneurial way. Can appropriately determine priorities in order to accomplish tasks and problems defined by themselves or others PEU_K02 Is able to work in a group, taking various roles in it.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Production of amorphoys and nanocrystalline metallic alloys by rapid quenching methods	2
Lec2	Microsructure studies and crystallization kinetics of amorphous alloys	2
Lec3	Soft and hard magnetic properties of ferromagnetoic amorphous and nanocrystalline alloys. Magnetocaloric and shape memory alloys.	2
Lec4	Mechanical properties analysis of multifunctional alloys	2
Lec5	Advanced, functional nanomaterials obtained by sol-gel method – general overview	2
Lec6	Differences in the production of various forms of sol-gel nanomaterials and methods of application.	2
Lec7	The variety of functionalisation methods for base sol-gel matrices	2
Lec8	POWDERS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec9	THIN FILMS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec10	AEROGELS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec11	Advanced measurement techniques in determining the mechanical properties of sol-gel nanomaterials	2
Lec12	Advanced mechanical properties of complex sol-gel materials	2
Lec13	Effects of magnetostriction, electrostriction and photostriction in advanced matarials	2
Lec14	When MEMS goes into NEMS	
Lec15	Case study - analysis of structural, surface and mechanical properties of chosen type of sol-gel materials and searching for potential applications	2

	Total hours	**30**

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Production of amorphous metallic ribbons and bulk metallic alloys	3
Lab2	Investigations of magneticaloric effect and other magnetic properties in wide range of temperature and magnetic field	3
Lab3	Mechanical parameters studies of multifunctional metallic materials with different grain size	3
Lab4	Different ways of powders, thin films and aerogels synthesis	3
Lab5	Methods of thin films application	3
Lab6	Structural and porosity analysis of different forms of sol-gel oxides	3
Lab7	Protection properties of sol-gel materials	3
Lab8	Optical properties of sol-gel materials	3
Lab9	Different way in determining the mechanical properties of sol-gel nanomaterials	3
Lab10	Cross-effect in advanced materials	3
	Total hours	**30**

Forma zajęć - Project		**Liczba godzin**
Pro1	Selection of production parameter of amorphous metallic ribbons and bulk metallic alloys	3
Pro2	Analysis of investigations of magnetocaloric effect and other magnetic properties in wide range of temperature and magnetic field and their influence on potential application	3
Pro3	Analysis of mechanical parameters of multifunctional metallic materials with different grain size and their influence on potential applications	3
Pro4	Influence of selected manufacturing parameters on the properties of the obtained materials and their final application	3
Pro5	Analysis of the influence of structure and porosity on the insulating properties of sol-gel materials	3
Pro6	Selection of protective parameters of sol-gel materials for the selected application	3
Pro7	Advanced methods in determining the mechanical properties of sol-gel nanomaterials	3
Pro8		3
Pro9	Design and development of device based on advanced materials	3
Pro10	Cross-effects for measurement techniques in nanotechnology	3
	Total hours	**30**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
P1 (lecture) F2 (classes) F3 (laboratory)	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K01 PEU_K02 PEU_U01 PEU_U02 PEU_K01 PEU_K02	Written exam Test Final Report note
P=0.6*F1+0.2*F2+0.2*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] K.H.J. Buschow, Handbook of Magnetic Materials, vol. 12, Elsevier Science
[2] M. Miller, P. Liaw, Bulk Metallic Glasses – An Overview, Springer
[3] Muhammed Musaddique Ali Rafique, Bulk metallic glasses and thei composites, Momentum Press
[4] C. J. Brinker and G. W. Scherer, Sol-gel Science: The Physics and Chemistry of Sol-gel Processing. San Diego: Gulf Professional Publishing, 1990
[5] D. Levy and M. Zayat, Eds., The Sol-Gel Handbook - Synthesis, Characterization, and Applications: Synthesis, Characterization and Applications. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2015

SECONDARY LITERATURE:

[1] P. W. Atkins, J. de Paula, and J. Keeler, Atkins' Physical Chemistry, 11th ed. Oxford: Oxford University Press, 2018
[2] Gross, D., & Seelig, T. (2017). *Fracture mechanics: with an introduction to micromechanics*. Springer.
[3] current literature in international journals, e.g. from *sciencedirect.com* database

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

PROF. JERZY KALETA
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WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Mechanika Analityczna**
Nazwa przedmiotu w języku angielskim: **Analytical Mechanics**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASM003002**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**	**15**	**15**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**60**	**30**	**60**		
Forma zaliczenia	**Egzamin**	**zaliczenie na ocenę***	**zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**2**	**1**	**2**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)		**1**	**1**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**	**0.7**	**0.6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Mathematical analysis (differential and integral calculus)
2. Linear algebra (matrices, determinants), geometry, trigonometry
3. Mechanics I and mechanics II in range of study stage I

CELE PRZEDMIOTU

C1. Knowledge of analytical methods for the application of Lagrangian mechanics in the dynamics of mechanical holonomic systems (for systems with constrains depending and not depending from time). Knowledge of vibration analysis of linear holonomic conservative systems with many degrees of freedom.
C2. Ability to independently analyze complex mechanical systems with a holonomic constrains

which are not depend on time to determine : differential equations of movement, natural vibration frequency spectrum, the modal matrix.

C3. The acquisition and consolidation of social skills including emotional intelligence relying ability to work in a group of students with a view to effective problem solving. Responsibility, honesty and fairness in conduct; observance of manners in the academic community and society

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

relating to knowledge:

PEU_W01 Students can define a discrete mechanical holonomic system and its possible and virtual displacements; know the fundamental problem of dynamics; know the classification of dynamical systems in respect of the constrain types; know the general equation of dynamics and the principle of virtual work..

PEU_W02 Students know the notion of generalized coordinates and configuration space of a dynamical system; know the concept of generalized forces (active and inertia); know the Lagrange's equations of the second kind

PEU_W02 Students know the vibration theory of linear systems with many degrees of freedom in the free vibration range.

relating to skills:

PEU_U01 Students are able to apply the virtual work principle and d'Alembert's principle for holonomic systems

PEU_U02 Students can derive the differential equations of motion of discrete dynamical systems by using Lagrange's equations and by using the energy conservation law for conservative holonomic systems.

PEU_U03 Students can calculate the spectrum of natural frequencies and can determine the modal matrix for discrete conservative linear systems.

relating to social competences:

PEU_K01 Students can search information and is able to critical review

PEU_K02 Students can objectively evaluate the arguments and rationally explain and justify own point of view.

PEU_K03 Students can observe the customs and rules of the academic community.

TREŚCI PROGRAMOWE

Forma zajęć - wykład		**Liczba godzin**
Wy1	Curriculum. Requirements. Examples of dynamic systems. Constrains and their types, classification systems for the sake of the constrain types (holonomic systems), possible velocities and possible displacements.	2
Wy2	The fundamental problem of dynamics, virtual displacement, the notion of ideal constraints, the general equation of dynamics, the virtual work principle.	2
Wy3	The dynamic general equation for the rotational and planar motion of rigid body (examples)	2
Wy4	Generalized coordinates. Derivation of differential equations of motion by usins the energy conservation law expressed in generalized coordinates (examples).	2
Wy5	Generalized forces. Configuration space. Lagrange's equations (of II type).	2
Wy6	Lagrange's equations (cont. examples, applications). Lagrangian.	2
Wy7	Linear systems with a finite number of degrees of freedom, matrix notation, conservative systems.	2
Wy8	Free vibrations of conservative systems: natural frequencies, modal	2

	matrices, mode shapes.	
Wy9	Harmonically forced vibration, frequency characteristics, an example of oscillation analysis of two- degree- of- freedom system.	2
Wy10	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.	2
Wy11	The dynamic equations for general motion of rigid body (Euler's equation).	2
Wy12	Gyroscope (approximate theory).	2
Wy13	An outline of linear elastic particle collisions theory, inelastic collision rate.	2
Wy14	Variational approach of Lagrangian mechanics.	2
Wy15	The central Lagrange's equation. Fundamental integral mechanical principle (Hamilton's principle)	2
	Suma godzin	**30**

Forma zajęć - ćwiczenia		**Liczba godzin**
Cl1	Introduction. Derivation of equations for possible velocities and virtual displacements.	2
Cl2	Solving of static problems by using a principle of virtual work	2
Cl3	Solving of dynamic problems for discrete systems by using a dynamic general equation (d'Alembert's principle).	2
Cl4	Solving of selected dynamic problems of a rigid body in plane motion by using a dynamic general equation.	2
Cl5	Derivation of motion differential equations based on the energy conservation law and Lagrange's equations (comparison of methods and results) for systems with one and two degrees of freedom	2
Cl6	Determination of the natural frequencies and modal parameters for conservative systems with two degrees of freedom	2
Cl6	Final test	2
Cl7	Credits. Improvement of marks	1
Cl8	Introduction. Derivation of equations for possible velocities and virtual displacements.	2
	Suma godzin	**15**

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Introduction. Getting familiar with the software Matlab and Simulink.	2
Lab2	Computer analysis of some dynamic system in case of plane motion by using dynamics equations of analytical mechanics	2
Lab3	Design by means of Simulink a dynamical system with one degree of freedom and computer analysis of the free and forced vibration.	2
Lab4	Analysis of free and forced vibration of a linear two-mass with two degrees of freedom system using Simulink software.	2
Lab5	Simulation studies a dynamic system proposed by the student and approved by the laboratory conductor.	2
Lab6	Experimental studies of vibration of selected real systems with a finite number of degrees of freedom (1 or/and 2). Introduction to the measuring	2

	apparatus, vibration sensors, methods of excitation, vibration analyzers, etc	
Lab7	Experimental investigation of a continuous dynamic system (beam and/or plate). Resonant frequencies, mode shapes.	2
Lab8	Evaluating the effects of activities, reports. Credits.	1
	Suma godzin	15

Forma zajęć - projekt		**Liczba godzin**
Pr1		

Forma zajęć - seminarium		**Liczba godzin**
Se1		

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	traditional lecture with the use of transparencies and slides
N2.	calculative-problematic exercises
N3.	tutorials
N4.	self study - preparation for laboratory class
N5.	self studies and preparation for examination

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1 (lecture)	PEU_W01, PEU_W02, PEU_W03, PEU_K01, PEU_K02, PEU_K03, PEU_U01, PEU_U02, PEU_U03	Calculative-problematic exercises
F2 (Classes)	PEU_U01, PEU_U02, PEU_U03	Final test, oral answers
F3 (laboratory)	PEU_K01, PEU_K02, PEU_K03, PEU_U01, PEU_U02, PEU_U03	laboratory reports, oral answer
P=0.6*F1+0.2*F2+0.2*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
LITERATURA PODSTAWOWA:
[1] Jerry Ginsberg, Engineering Dynamics, Cambridge

[2] Meriam, Kraige, Dynamics
[3] Gross D., Hauger W., Schroder J., Wall W.A., Govindjee S., Engineering Mechanics 3, Springer
[4] Housner G.W., Hudson D.E., Applied Mechanics – Dynamics
[5] M. Lunn, A First Course in Mechanics, Oxford Science Publications, 1991.

LITERATURA UZUPEŁNIAJĄCA:

[1] J. Zawadzki, W. Siuta, "General Mechanics", PWN, Warsaw, 1971;
[2] B. Skalmierski, "Mechanics", PWN, Warsaw, 1982;
[3] M. Kulisiewicz St. Piesiak, "Methodology of modeling and identification of mechanical dynamical systems", WUT. , 1994;
[4] J. Leyko, "General Mechanics", WNT, Warsaw, 1980;
[5] J. Giergiel, "General Mechanics", WNT, Warsaw, 1980.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

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WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Projektowanie Materiałów Inżynierskich**
Nazwa przedmiotu w języku angielskim:	***Design of Engineering Materials***
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	
Stopień studiów i forma:	**~~I~~ / II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~**/ wybieralny /**~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASM003003**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**			**30**	
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**60**			**60**	
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**			**2**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**1**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**			**0.7**	

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Basic knowledge in such disciplines as: Materials science, Strength of materials, Manufacturing technology, processing and recycling of materials, design and examination methods of structure and properties of materials
2. Skills in usage of technical data and specialized computer software.
3. Skills in collaboration with other users of engineering materials and specialists in the fields of design, manufacturing, processing, and application of materials.

CELE PRZEDMIOTU

C1. Obtaining the skills in design of chemical composition and structure of engineering materials to

produce products with desired mechanical and operational properties.
C2. Obtaining the skills in materials selection for technical applications)
C3. Obtaining the skills in failure analysis of materials and design of repair processes for improvement of products durability.
C4. Acquisition of basic knowledge in the development of scientific expertises

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
Z zakresu wiedzy: PEU_W01 - Possesses advanced knowledge on structure- properties relationship as well as on strengthening mechanisms in materials and their practical usage for material design of products. PEU_W02 - Knows the criteria and methodology of materials selection and can participate in engineering design of products. Z zakresu umiejętności: PEU_U01 – Able to design the materials structure in order to obtain the desired operational properties of product. PEU_U02 – Able to conduct the failure analysis of material and design the repair process for improvement of product durability. Z zakresu kompetencji społecznych: PEU_K01 – Possesses the collaboration skills and able to lead the research teams in engineering design process. PEU_K02 – Is prepared to conduct the research on materials design of products.

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Introduction to design of metallic materials. Effect of chemical composition, processing and microstructure on the properties of materials.	2
Lec2	The role and significance of alloy phase diagrams in design of materials.	2
Lec3	Strengthening mechanisms in metals and alloys - theory and practice	2
Lec4	Influence of manufacturing technology on selected properties of metallic alloys	2
Lec5	Tailored material properties for engineering applications using incremental techniques - techniques, properties - strength analysis	2
Lec6	The role of manufacturing defects on the residual strength of materials	2
Lec7	Design of non-metallic materials - an introduction to fibrous composites	2
Lec8	Manufacturing technologies of composite materials	2
Lec9	Forming machine parts of composite materials - design philosophy	2
Lec10	Thermpolastic matrix composites - examples of fabrication and strength orienting tailored structures	2
Lec 11	Duroplastic matrix composites - examples of manufacturing and strength orienting of tailored structures	2
Lec 12	An example of individualized material design for engineering applications - case study analysis	2
Lec13	Hyperelastic materials and modeling of mechanical behavior	2
Lec14	Metal matrix composites - fundamentals in design.	2
Lec15	Criteria and quantitative methods of materials selection in engineering design.	2
	Total hours	**30**

Forma zajęć - laboratorium		Liczba godzin
Proj1	Selection of material for chosen structural component	2
Proj2	Design of chemical composition of steel with desired hardenability.	2
Proj3	Design of microstructure of steel in the process of heat treatment - part I.	2
Proj4	Design of microstructure of steel in the process of heat treatment - part II.	2
Proj5	Selection of material for selected structural component - project- part II.	2
Proj6	Design of metallic materials using additive technologies for specific complex structures	4
Proj7	Rapid Prototyping of products made of polymers and ceramics	4
Proj8	Design of composite materials and pultrusion system for manufacturing closed and open sections for industrial application	2
Proj9	Selection of composite materials for cylindrical structures and design of manufacturing methods	2
Proj10	Hybrid layered materials – design and selection of manufacturing processes	2
Proj11	Case study I – fatigue resistance materials design and selection	2
Proj12	Case study II – creep resistant material design and selection	2
Proj13	Preparation of reports and discussion of the selected issue - the design of the production of a material tailored to the operational requirements	2
	Total hours	**30**

STOSOWANE NARZĘDZIA DYDAKTYCZNE
N1. multimedia presentation N2. personal computer, interactive whiteboard (calculations, drawings, descriptions), N3 project presentation

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1 (lecture)	PEU_W01, PEU_W02	Written exam
P=F1		
F2 (project)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Evaluation and defense of a developed project
P=F2		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
LITERATURA PODSTAWOWA:

[1] Ashby, M. F., & Jones, D. R. (2012). Engineering materials 1: an introduction to properties, applications and design (Vol. 1). Elsevier.
[2] Barbero, E. J. (2017). *Introduction to composite materials design*. CRC press.
[3] Ashby, M. F., Shercliff, H., & Cebon, D. (2018). *Materials: engineering, science, processing and design*. Butterworth-Heinemann.
[4] BROCKS, Wolfgang. Plasticity and Fracture. Springer International Publishing, 2018.
[5] Bank, L. C. (2006). *Composites for construction: structural design with FRP materials*. John Wiley & Sons.

LITERATURA UZUPEŁNIAJĄCA:

[1] Mueller, B. (2012). Additive manufacturing technologies–Rapid prototyping to direct digital manufacturing. *Assembly Automation*.
[2] Gu, D. (2015). *Laser additive manufacturing of high-performance materials*. Springer.
[3] Bart, J. C. (2005). „Additives in polymers. *Industrial analysis and application*.
[4] Chua, C. K., Wong, C. H., & Yeong, W. Y. (2017). *Standards, quality control, and measurement sciences in 3D printing and additive manufacturing*. Academic Press.
[5] Campbell Jr, F. C. (Ed.). (2003). *Manufacturing processes for advanced composites*. elsevier..

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

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Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Mechanika Pękania**
Nazwa przedmiotu w języku angielskim:	**Fracture mechanics**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Stopień studiów i forma:	**~~I~~ / II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASM003004**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**	**15**	**15**		
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**	**30**	**30**		
Forma zaliczenia	**Egzamin /** ~~zaliczenie na ocenę~~*	~~Egzamin /~~ **zaliczenie na ocenę***	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**	**1**	**1**		
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)		**1**	**1**		
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)		**0.6**	**0.6**		

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH
1. Knowledge of Mechanics& Strength of Materials principles. 2. Knowlege of differential equations and fundamental linear algebra. 3. Knowledge of basic experimental mechanics

CELE PRZEDMIOTU
C1. To learn the stress field parameters in front of the crack tip C2. Knowledge of experimental methods of fracture mechanics including determination of fracture

toughness measures for engineering materials (metals, composites, polymers)
C3. To learn fatigue crack propagation model identification and fatigue crack growth analysis - fatigue lifetime calculation
C4. Learn to analyze the fracture and crack growth process under complex stress conditions
C5. Be able to know the fracture pattern and determine the cause of failure of a structural members
C6. Acquiring skills of scientific cooperation in a team analyzing fatigue damage.
C7. Acquisition of basic knowledge in the development of scientific expertises

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: PEU_W01 Knowledge of linear and nonlinear models of fracture mechanics. PEU_W02 Knowledge of methods for fatigue crack growth lifetime calculation under uniaxial and multiaxial loading conditions relating to skills: PEU_U01 Can estimate fundamental parameters of fracture mechanics like K, J, G for structural members PEU_U02 Can use mathematical and experimental methods for fatiguelifetime prediction relating to social competences: PEU_K01 Can objectively evaluate the arguments as well as rationally explain and justify the own point of view. PEU_K02 Can search information and is able to review it critically

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Liczba godzin**
Lec1	Theoretical Strength of Materials – defects in materials	2
Lec2	Griffith's theory and elastic stress field – Stress intensity factor definition	2
Lec3	Plastic zones ahead of a crack tip, nonlinear fracture mechanics (CTOD, J)	2
Lec4	Brittle and ductile fracture of metals, polymers and composites– fractography analysis	2
Lec5	Experimental methods in fracture mechanics and fatigue of materials – determination of the characteristics in a uniaxial loading condition	2
Lec6	Initiation of fatigue cracks in the material - microstructural aspects of the fatigue process. Low- and high-cycle Fatigue	2
Lec7	Fatigue crack growth (mode I); fatigue crack growth curve, micro-crack growth mechanisms.	2
Lec8	Factors influencing fatigue crack growth rates	2
Lec9	Fundamentals of the degradation theory and its influence on fatigue and fracture properties of materials and structures	2
Lec10	Multiaxial stress state; fracture toughness characterization	2
Lec 11	Mixed-mode fatigue cracks growth. Predicting of fatigue crack paths and fatigue lifetime estimation	2
Lec 12	Multiaxial fatigue - an overview of existing solutions for proportional and non-proportional loads	2
Lec13	Variable and random loading – calculation methods and fatigue damage rules	2
Lec14	Case study - analysis of fatigue crack growth in structural components and damage analysis - example of expertise elaboration - description of a fracture surface	2

Lec15	The probabilistic approach in fracture mechanics and defect tolerance modelling	2
	Total hours	**30**

Forma zajęć - ćwiczenia		**Liczba godzin**
Cl1	Solving of the exercises with a solid body containing cracks using linear elastic fracture mechanics	2
Cl2	Solving of the exercises s with a solid body containing cracks using elastoplastic fracture mechanics	2
Cl3	Fatiguelifetime calculations with Paris law using standardized specimens and SIF solutions	2
Cl4	Fatiguelifetime calculations with Paris law using complex geometry structural members	2
Cl5	Fatiguelifetime calculations under variable amplitude loading conditions	2
Cl6	Fatiguelifetime calculations and crack paths analysis under mixed-mode loading conditions	2
Cl7	Case study calculation analysis – solution of the complex problem of structural members and structures in the scope of fatigue and fracture	2
Cl8	Test and own analysis of the selected problem	1
	Total hours	**15**

Forma zajęć - laboratorium		**Liczba godzin**
Lab1	Fracture toughness – K determination for metals and non-metals	2
Lab2	Fracture toughness – G determination for composite materials	2
Lab3	Nonlinear elasto-plastic parameters determination (J, CTOD) for metals	2
Lab4	Fracture characterization of polymers (Essential Work of Fracture)	2
Lab5	Mixed-mode fracture toughness characterization of materials	2
Lab6	Fatigue crack growth rate measurement and crack closure evaluation	2
Lab7	Mixed-mode fatigue crack growth	2
Lab8	Evaluation of reports – final report note evaluation	1
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1 (lecture)	PEU_W01, PEU_W02	Written exam
F2 (classes)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Test
F3 (laboratory)	PEU_U01	Final Report note

	PEU_U02 PEU_K01 PEU_K02	
P=0.6*F1+0.2*F2+0.2*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

LITERATURA PODSTAWOWA:

[1] Anderson T.L. Fracture Mechanics. Fundamentals and Applications, Fourth Edition. — CRC Press,
[2] Gdoutos, E. E. (2020). Fracture mechanics: an introduction (Vol. 263). Springer Nature.
[3] Farahmand, B., Bockrath, G., & Glassco, J. (2012). *Fatigue and fracture mechanics of high risk parts: application of LEFM & FMDM theory*. Springer Science & Business Media.
[4] BROCKS, Wolfgang. Plasticity and Fracture. Springer International Publishing, 2018.
[5] Avellar, L., & Mac Donald, K. (2019). Mechanics of Materials and Fracture for High School Students. In Fracture, Fatigue, Failure and Damage Evolution, Volume 6 (pp. 111-114). Springer, Cham.

LITERATURA UZUPEŁNIAJĄCA:

[1] Lesiuk, G., Correia, J.A.F.O., Krechkovska, H.V., Pekalski, G., Jesus, A.M.P. de, Student, O., Degradation Theory of Long Term Operated Materials and Structures, Springer, 2021
[2] Saxena, A. (2019). Advanced Fracture Mechanics and Structural Integrity. CRC Press.
[3] BROEK, David. *The practical use of fracture mechanics*. Springer Science & Business Media, 2012.
[4] Moore, D. R., Williams, J. G., & Pavan, A. (2001). *Fracture mechanics testing methods for polymers, adhesives and composites*. Elsevier.
[5] Gross, D., & Seelig, T. (2017). *Fracture mechanics: with an introduction to micromechanics*. Springer.

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Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Inżynieria wynalazczości**
Nazwa przedmiotu w języku angielskim: **Inventive Engineering**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy): **Mechanics of Materials (MM)**
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASM003005**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**			**15**	
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**60**			**90**	
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**2**			**3**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**1**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)				**0.6**	

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. The ability to design technical objects.
2. Ability to model CAD geometric parts and assemblies.
3. Ability to work in a team.

CELE PRZEDMIOTU

C1. Acquiring knowledge about the methods of designing inventions with high innovative potential using systematic and heuristic methods.
C2. Acquisition of knowledge in the field of innovation assessment using objective methods.
C3. Acquisition of knowledge in the area of building inventive teams and acquiring knowledge

C4. Acquiring the skills of conceptual design with the use of prototyping
C5. Acquiring the ability to plan and conduct inventive workshops using heuristic and systematic methods such as TRIZ, Synectics, Design Thinking
C6. Acquiring skills in the field of commercialization of inventions and financing engineering

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ

relating to knowledge:
PEU_W01 Student knows and understands the cycle of conceptual design according to the Inventive methodology Engineering.
PEU_W02 A student has knowledge of conceptual design and prototyping products and services
PEU_W03 A student has knowledge of the development of a design concept and engineering of financing the commercialization of inventions

relating to skills:
PEU_U01 A student is able to design a prototype of a finished product and conduct inventive sessions.
PEU_U02 A student is able to generate conceptual solutions based on heuristic and systematic methods
PEU_U03 A student is able to develop a design concept into a finished product using CAD modeling

relating to social competences:
PEU_K01 A student understands the need for continuous self-improvement in the work of an engineer.
PEU_K02 A student is able to use creativity in everyday work and draw inspiration from it to solve technical problems
PEU_K03 The student is able to plan activities aimed at carrying out a full product development cycle based on the Inventive Engineering methodology.

TREŚCI PROGRAMOWE

Forma zajęć - wykład		**Number of hours**
Lec1	Methods and tools of inventive design	2
Lec2	Overview of the methodology of Inventive Engineering	2
Lec3	Product and service innovation assessment	2
Lec4	Forecasting the development of products and services - phase "For"	2
Lec5	Forecasting the development of products and services – phase "Model"	2
Lec6	Forecasting the development of products and services - phase Analyzes"	2
Lec7	Forecasting the development of products and services - phase "Transfer"	2
Lec8	Building inventive teams	2
Lec9	Heuristic and systematic knowledge acquisition	2
Lec10	Conceptual design using heuristic methods	2
Lec11	Conceptual design using systematic methods	2
Lec12	Development of the design concept in terms of TEES changes: technical and technological, economic, environmental and social	2
Lec13	Financing engineering - preparing a budget for the development and commercialization of inventions and raising funds for the development of inventions and their commercialization. Part 1	2
Lec14	Financing engineering - preparing a budget for the development and commercialization of inventions and raising funds for the development of inventions and their commercialization. Part 2	2
Lec15	Evaluation classes	2

	Total hours	**30**

Forma zajęć - laboratorium		**Liczba godzin**
Proj1	Overview of the organization and schedule of activities. Selection of a case study for further analysis	2
Proj2	Assessment of the innovation of the selected product or service	2
Proj3	Forecasting the development of the selected product or service – phase "For"and "Model"	2
Proj4	Forecasting the development of the selected product or service – phase „Analyzes" and "Transfer"	2
Proj5	Problem definition in the, context of effect and cause, conceptual design	2
Proj6	Heuristic and systematic knowledge acquisition	2
Proj7	Development of the design concept and its commercialization	2
Proj8	Evaluation of reports – final report note evaluation	1
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE
N1. traditional lecture with the use of transparencies and slides N2. problem discussion N3. case study N4. self study - preparation for project class N5. multimedia presentation

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture) F2 (project)	PEK_W01, PEK_W02, PEK_W03 PEK_U01, PEK_U02, PEK_K01, PEK_K02, PEK_K03	Test Project preparation evaluation, project defense
P=F1		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA
PRIMARY LITERATURE: [1] S. Koziołek. Inventiveness Engineering. Methodology of designing innovative technical systems. Publishing house of Wrocław University of Technology, first edition. Wroclaw 2019. [2] T. Arciszewski, Inventive Engineering: Knowledge and Skills for Creative Engineers. Taylor&Francis, 2016. [3] W. J. J. Gordon, SYNECTICS. The Development of Creative Capacity. New York: Macmillan Publishing Co., Inc., 1961. **SECONDARY LITERATURE:** [1] S. Koziołek i T. Arciszewski, „Syntectical Building of Representation Space: a Key to Computing Education", w Computing in Civil Engineering, 2011, ss. 1–15. [2] L. Haines-Gadd, TRIZ For Dummies. Wiley, 2016.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

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Wroclaw University of Science and Technology
Faculty of Mechanical Engineering, Department of Machine Design and Research

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim: **Modelowanie układów wielczłonowych**
Nazwa przedmiotu w języku angielskim: **Modeling of multibody systems**
Kierunek studiów (jeśli dotyczy): ***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):
Stopień studiów i forma: ~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu: **obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu: **ASM003006**
Grupa kursów: ~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)				**60**	
Liczba godzin całkowitego nakładu pracy studenta (CNPS)				**150**	
Forma zaliczenia	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS				**5**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**3**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)				**1.4**	

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Knowledge of the theory of machines and mechanisms
2. Ability to analyze classical kinematics and kinetostatics
3. Elemental knowledge of solid modeling using CAD / CAE systems

CELE PRZEDMIOTU

C1. Understanding of building discrete computational models of multibody systems
C2. Knowing and understanding the principles of research planning, taking into account working conditions (e.g. kinematic excitations, dynamic loads, loads - including mass loads) of multi-unit systems in computer systems dynamic analyzes
C3. Acquiring by the student the ability to critically evaluate the obtained results of simulation of

machinery in computer systems of dynamic analysis

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
Z zakresu umiejętności: PEU_U01 Ability to apply a professional computer system for simulation and dynamic analysis of multibody systems PEK_U02 The ability to model the load conditions and the nature of the mechanism's work and the ability to analyze the obtained results from the simulation of the operation of a multibody system PEK_U03 Ability to compute the kinematics and dynamics of selected groups of mechanisms Z zakresu kompetencji społecznych: PEU_K01 acquiring the ability to take responsibility for the own work PEK_K02 acquires care for the aesthetics of the performed work, including projects and reports

TREŚCI PROGRAMOWE		
Forma zajęć - projekt		**Liczba godzin**
Proj 1	An introduction to the principles of building multibody models	2
Proj 2	Basics of modeling mechanisms in MD.Adams – modeling links, kinematic pairs, kinematic contrains and kinematic excitations	6
Proj 3	Basics of modeling mechanisms in MD.Adams – modeling loads, performing calculations and analysis of the results	6
Proj 4	The test of modeling a multibody system	4
Proj 5	Kinematic and kinetostatic analysis of linkage mechanisms - virtual models construction	4
Proj 6	Analysis of kinematic and dynamic properties of the linkage mechanism (project)	4
Proj 7	Gear meachnism analysis (fixed, planetary and differential) - building principles of virtual models	4
Proj 8	Analysis of kinematic and dynamic of gears (project)	6
Proj 9	Construction of spacial manipulator models for direct and inverse kinematics task	4
Proj 10	Simulation studies of spacial manipulator (project)	6
Proj 11	Building models of spatial systems - constraints, excitations, loads	6
Proj 12	Modeling and simulations of spatial systems (project)	6
	Total hours	**60**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	self-study - preparation for the project
N2.	multimedia presentation
N3.	interactive whiteboard (calculations, drawings, descriptions)
N4.	project presentation
N5.	consultation and tutorials

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Numer efektu uczenia się	Sposób oceny osiągnięcia efektu uczenia się
F1	PEK_U01-PEK_U03 PEK_K01-PEK_K02	Evaluation of test
F2	PEK_U01-PEK_U03 PEK_K01-PEK_K02	The average of projects evaluation
$P = 0{,}2 \cdot F1 + 0{,}8 \cdot F2$		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] Gronowicz A.: Podstawy analizy układów kinematycznych. Oficyna Wydawnicza PWr., Wrocław 2003.
[2] Frączek J., Wojtyra M.: Metoda układów wieloczłonowych w dynamice mechanizmów. Oficyna Wydawnicza
[3] Politechniki Warszawskiej, Warszawa 2007
[4] MD. Adams – Reference Manual, 2008.
[5] Haug E.J.: Computer Aided Kinematics and Dynamics of Mechanical Systems. Allyn and Bacon, Boston 1989
[6] Norton R., L.: Design of Machinery, An introduction to the synthesis and analysis of mechanisms of machines.
[7] WCB, McGraw-Hill, Boston, 1999.
[8] Shabana A. Ahmed: Computational Dynamics, . A Wiley-Interscience Publications, NewYork, 1994.

SECONDARY LITERATURE:

[1] Miller S.: Teoria maszyn i mechanizmów. Analiza układów mechanicznych. Oficyna wydawnicza PWr. Wrocław 1996.
[2] Waldron J., Kinzel G.; Kinematics, dynamics and design of machinery, John Wiley & Sons, Inc. New York, 1999

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

PhD Artur Handke, artur.handke@pwr.edu.pl
Department of Fundamentals of Machine Design and Mechatronic Systems - W10 / K61;

Załącznik nr 6 do ZW 121/2020

WYDZIAŁ BUDOWNICTWA LĄDOWEGO I WODNEGO

KARTA PRZEDMIOTU

Nazwa przedmiotu w języku polskim:	**Teoria i inżynieria niezawodności i eksploatacji**
Nazwa przedmiotu w języku angielskim:	**Reliability and Maintenance Theory and Engineering**
Kierunek studiów (jeśli dotyczy):	***Advanced Solid Mechanics***
Specjalność (jeśli dotyczy):	**Mechanics of Materials (MM)**
Stopień studiów i forma:	~~I~~ **/ II stopień*, stacjonarna /** ~~niestacjonarna~~*****
Rodzaj przedmiotu:	**obowiązkowy** ~~/ wybieralny /~~ ~~ogólnouczelniany~~*****
Kod przedmiotu:	**ASM003007**
Grupa kursów:	~~TAK~~ **/ NIE***

	Wykład	Ćwiczenia	Laboratorium	Projekt	Seminarium
Liczba godzin zajęć zorganizowanych w Uczelni (ZZU)	**30**			**15**	
Liczba godzin całkowitego nakładu pracy studenta (CNPS)	**90**			**60**	
Forma zaliczenia	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*	Egzamin / zaliczenie na ocenę*	~~Egzamin /~~ **zaliczenie na ocenę***	Egzamin / zaliczenie na ocenę*
Dla grupy kursów zaznaczyć kurs końcowy (X)					
Liczba punktów ECTS	**3**			**2**	
w tym liczba punktów odpowiadająca zajęciom o charakterze praktycznym (P)				**1**	
w tym liczba punktów ECTS odpowiadająca zajęciom wymagającym bezpośredniego udziału nauczycieli lub innych osób prowadzących zajęcia (BU)	**0.6**			**0.6**	

*niepotrzebne skreślić

WYMAGANIA WSTĘPNE W ZAKRESIE WIEDZY, UMIEJĘTNOŚCI I KOMPETENCJI SPOŁECZNYCH

1. Has a basic knowledge of design and testing of technical processes/systems
2. Has a basic knowledge in the field of applied mathematics
3. Has a basic knowledge in the field of spreadsheet using, e.g. Excel

CELE PRZEDMIOTU
C1. The acquisition of the extended knowledge in the areas of maintenance management and dependability management of technical systems and their supporting systems. C2. The acquisition of the basic knowledge in the areas of basic methods, tools, techniques and materials used to solve complex engineering tasks in the field of reliability, maintenance, and risk management of technical systems. C3. Acquiring the ability to solve the real-life problems, which may affect the effective performance of technical systems. C4. Acquiring the ability to design operation and maintenance processes, taking into account the need to ensure the desired level of operational availability and financial efficiency.

PRZEDMIOTOWE EFEKTY UCZENIA SIĘ
relating to knowledge: **PEU_W01** A student has extended knowledge of the operation and maintenance, dependability and safety of technical objects/systems **PEU_W02** Learn about development trends in technology and organization of operation and maintenance of technical objects/systems relating to skills: **PEU_U01** Able to use the known methods and mathematical models to analyze and design reliable technical objects/systems **PEU_U02** Can make rational decisions in the aspect of technical systems operation and maintenance management performance relating to social competences: **PEU_K01** Is able to properly prioritize the implementation of the tasks specified by him or others **PEU_K02** Can work in a group. He can lead a small team by taking responsibility for the effects of his work

TREŚCI PROGRAMOWE		
Forma zajęć - wykład		**Number of hours**
Lec1	Introduction to reliability engineering. Reliability management systems	2
Lec2	Processes leading to damage and failures. Classification and causes of failures	2
Lec3	Reliability modelling of irreparable component. Characteristics and indicators of reliability. Physical and statistical interpretation of reliability indicators	2
Lec4	Reliability modelling of unrecoverable technical systems. Basic reliability structures	2
Lec5	Reliability modelling of unrecoverable technical systems. Complex reliability structures	2
Lec6	Stochastic processes in reliability. The Poisson process and the birth and death process	2
Lec7	Markov processes.	2
Lec8	Technical object operation and maintenance problems - the main terms and definitions. System of operation and maintenance and its models	2
Lec9	Maintenance strategies and operating and maintenance prevention. Potential	2

	for operation and maintenance	
Lec10	Maintenance strategies – LCC, RCM, RBM	2
Lec 11	Introduction to safety and risk management in technical systems	2
Lec 12	Tools and methods of technical object/system failure analysis (FMEA/FMECA)	2
Lec13	Risk analysis methods (FTA, ETA, PHA, PSA, HAZOP)	2
Lec14	Costs in maintenance and operation process performance. Reliability – cost or profit?	2
Lec15	Evolution of the reliability and safety theories – trends in development	2
	Total hours	**30**

Forma zajęć - Project		**Liczba godzin**
Proj1	Introduction to the project course. Reliability analysis of technical objects (e.g. evaluation of reliability/unreliability functions, failure intensity)	3
Proj2	The use of conformance tests to assess the reliability of technical objects	2
Proj3	Analysis of technical objects reliability structure, definition of optimal warranty period for the specified assumptions	2
Proj4	Maintenance strategy selection with taking into account economic and reliability criteria	2
Proj5	Repairman problem	2
Proj6	Technical object failure analysis with the use of FMEA method	2
Proj7	Maintenance analyzes. Impact of operational conditions on reliability parameters	2
	Total hours	**15**

STOSOWANE NARZĘDZIA DYDAKTYCZNE	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW UCZENIA SIĘ		
Oceny (F – formująca (w trakcie semestru), P – podsumowująca (na koniec semestru)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Test
F2 (Project	PEU_U01 PEU_U02	Test
F3 (Project)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Active work during project activities
P=0.6*F1+0.3*F2+0.1*F3		

LITERATURA PODSTAWOWA I UZUPEŁNIAJĄCA

PRIMARY LITERATURE:

[1] [1] Aven, T. Quantitative risk assessment: the scientific platform. New York: Cambridge University Press, 2011.
[2] De Almeida, A.T. Multicriteria and multiobjective models for risk, reliability and maintenance decision analysis. Springer, 2015
[3] Dhillon, B.S. Maintainability, maintenance, and reliability for engineers. Boca Raton: CRC/Taylor & Francis, 2006
[4] Frenkel, I.B., Karagrigoriou, A., Lisnianski, A. (eds.) Applied reliability engineering and risk analysis: probabilistic models and statistical inference. Chichester, West Sussex: Wiley, 2014.
[5] Jardine, A.K.S., Tsang, A.H.C. Maintenance, replacement, and reliability: theory and applications. Boca Raton : CRC Press/Taylor & Francis Group, 2017
[6] Nash, F.R. Reliability assessments: concepts, models and case studies. Boca Raton etc.: CRC Press/Taylor & Francis Group, 2016
[7] Stapelberg, R.F., Handbook of reliability, availability, maintainability and safety in engineering design. London: Springer Verlag London Limited, 2009.
[8] Verma, A.K., Srividya, A., Karanki, D.R. Reliability and safety engineering. London etc.: Springer-Verlag, 2016

SECONDARY LITERATURE:

[1] Jin, T. Reliability engineering and services. Hoboken : Wiley & Sons, 2019
[2] Nakagawa, T. Random maintenance policies. Springer Series in Reliability Engineering, 2014
[3] Werbińska-Wojciechowska, S. Technical System Maintenance. Delay-Time-Based Modelling, Springer, 2019
[4] Zio, E., Baraldi, P., Cadini, F. Basics of reliability and risk analysis: worked out problems and solutions. New Jersey etc.: World Scientific, 2011.

OPIEKUN PRZEDMIOTU (IMIĘ, NAZWISKO, ADRES E-MAIL)

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Department of Operation and Maintenance of Technical Systems, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology

Zał. Nr 1 do ZW 16/2020

PROGRAM OF STUDIES

FACULTY: **Civil Engineering, Mechanical Engineering**
MAIN FIELD OF STUDY: **Advanced Solid Mechanics**
DISCIPLINES: **D1 Civil engineering and transport (major discipline)**
D2* Mechanical engineering
~~D3*~~ ……
~~D4*~~ ……

EDUCATION LEVEL: **~~first-level (licencjat/inżynier) studies~~ / second-level studies ~~/ magister uniform studies~~***
FORM OF STUDIES: **full-time studies / ~~part-time studies~~***
PROFILE: general academic / ~~practical~~ *
LANGUAGE OF STUDY: **English**

Content:

Resolution no. … of the Senate of Wroclaw University of Science and Technology

In effect since 1.10.2021

*delete as applicable

ASSUMED LEARNING OUTCOMES

Faculty: **Civil Engineering, Mechanical Engineering**
The main field of study: **Advanced Solid Mechanics**
Education level: **second-level studies**
Profile: **general academic profile**

Location of the field of study
Branch of science: engineering and technical sciences
Discipline/discipline for several disciplines, please indicate the leading discipline)
Civil engineering and transport (major discipline)

Explanation of the markings:
P6U – universal first degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7U – universal first degree characteristics corresponding to education at the second-level studies - 7 PRK level *

P6S – second degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7S – second degree characteristics corresponding to education at the second-level studies - 7 PRK level *

W - category "knowledge"
U - category "skills"
K - category "social competences"
K (*faculty symbol*) _W1, K (*faculty symbol*) _W2, K (*faculty symbol*) _W3, … - main-field-of study learning outcomes related to the category "knowledge"
K (*faculty symbol*) _U1, K (*faculty symbol*) _U2, K (*faculty symbol*) _U3, … - main-field-of study learning outcomes related to the category "skills"
K (*faculty symbol*) _K1, K (*faculty symbol*) _K2, K (*faculty symbol*) _K3, … - main-field-of study learning outcomes related to the category "social competences"
S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., … - specialisation learning outcomes related to the category "knowledge"
S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., … - specialisation learning outcomes related to the category "skills"
S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., … - specialisation learning outcomes related to the category "social competences"

Note: the effects with the U code are obtained only during practical classes.

The main field of study learning outcomes	Description of learning outcomes for the main-field-of study	Reference to PRK characteristics		
		Universal first-degree characteristics (U)	Second-degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels PRK	Characteristics for qualifications on 6 and 7 levels of PRK, enabling acquiring engineering competences
KNOWLEDGE (W)				
K2_W01	possess the bordered knowledge in the area of mathematics necessary to description and analysis of solid materials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W02	possess the necessary knowledge about the theoretical basis of numerical methods for modelling and analysis of engineering structures and mechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W03	knows the advanced topics in theoretical mechanics and structures	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W04	possess the essential knowledge in the area of continuum mechanics concept and mathematical description related to the mechanics and structure problems.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W05	possess grounded knowledge about the theoretical basis of constitutive laws.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W06	possess advanced knowledge in the area of dynamics and vibration aspects related to mechanics and structural engineering.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W07	knows the classification and the range of applications of computer programs supporting the analysis and design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W08	know principles of structure models, analysis and design of structural systems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W09	possesses the necessary knowledge about the interaction of structure with the environment	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W10	knows standard, guidelines and regulations relevant to the structure design	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2_W11	knows currently used, modern building materials and essential components of technologies and their production	**P7U_W**	**P7S_WG, P7S_WK**	**P7S_WG_INZ, P7S_WK_INZ**
K2_W12	knows the characteristics of analysis and structure optimisation as well as intricate structure system design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W13	knows the method of solving problems related to the theory of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W14	possessing advanced knowledge on structure-properties relationship for material design of products.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2_W15	knows the fundamentals and design philosophy of modern engineering materials.	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2_W16	extended knowledge of systems modelling	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
	achieves outcomes in the category of KNOWLEDGE in one of the following specialisations: • run in the English language - Mechanics of Structure (**K2S_MS_W**) (appendix I) - Mechanics of Materials (**K2S_MM_W**) (appendix II)			

SKILLS (U)				
K2_U01	can use advanced specialist tools that support the design process related to the discipline of civil engineering and transport as well as mechanical engineering; know how to use information technologies for communication and knows how to choose software that supports the work of a designer	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U02	have the ability to solve engineering problems using the analytical or numerical tools	**P7U_U**	**P7S_UW**	
K2_U03	know how to establish directions for further education and follow the process of self-learning	**P7U_U**	**P7S_UK, P7S_UU**	
K2_U04	can use advanced methods of mechanics and the theory of structures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U05	can critically assess the results of numerical analysis	**P7U_U**	**P7S_UW , P7S_UU**	**P7S_UW_INZ**
K2_U06	can prepare a graphics project documentation	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U07	know how to assess threats related to projects and implement adequate safety principles, and can develop norms and standards of work and quality	**P7U_U**	**P7S_UW, P7S_UK, P7S_UO, P7S_UU**	**P7S_UW_INZ**
K2_U08	understand how to solve complex concepts in the area of chosen sections of mathematics, being the basis of advanced construction analysis methods; can choose tools (analytical or numerical) to solve engineering problems; can use chosen computer programs supporting modelling and design processes in civil engineering	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U09	can plan and carry laboratory experiments leading to quality assessment of applied materials and also the assessment of the strength	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U10	can acquire and apply information from literature, databases and other available sources to engineering activities in the field of design, operation of machinery and manufacturing techniques	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U11	is able to prepare a presentation on a selected topic	**P7U_U**	**P7S_UW, P7S_UK**	**P7S_UW_INZ**
K2_U12	know how to perform material selection and develop design assumptions based on performance requirements of structural elements or assemblies of machines and facilities	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2_U13	is able to, according to scientific principles, using scientific know-how to formulate and develop entry works of a research type leading to solving engineering problems as well as technological and organisational	**P7U_U**	**P7S_UW, P7S_UU**	**P7S_UW_INZ**
K2_U14	is able to plan, prepare and carry out research and prepare elaborations which prepare him/her to take up research work	**P7U_U**	**P7S_UW, P7S_UK , P7S_UU**	**P7S_UW_INZ**

	achieves outcomes in the category of SKILLS in one of the following specialisations: • run in the English language - Mechanics of Structure (**K2S_MS_W**) (appendix I) - Mechanics of Materials (**K2S_MM_W**) (appendix II)			
COMPETENCES (K)				
K2_K01	understand aware of the need to improve professional and personal competences continually; in the form of formal or informal education, it complements and expands knowledge in the field of modern processes and technologies related to civil engineering and transport as well as mechanical engineering	**P7U_K**	**P7S_KK**	
K2_K02	realises the significance and understands non-technical aspects and consequences of engineering activity and especially its influence on the natural environment and the related responsibility for decisions	**P7U_K**	**P7S_KK, P7S_KO**	
K2_K03	can work independently and cooperate in a group on given tasks; is responsible for the safety of his work as well as his team	**P7U_K**	**P7S_KK, P7S_KO**	
K2_K04	realises the significance of professional behaviour and obey the code of ethics; identifies correctly and solve dilemmas related to the profession; is able to set priorities that help in implementing a task set by himself or others	**P7U_K**	**P7S_KO, P7S_KR**	
K2_K05	can think and act in a creative and entrepreneurial way	**P7U_K**	**P7S_KO**	
K2_K06	realises the social role of technical university graduates and especially understands the need to formulate information and share it with society, e.g. through mass media, concerning achievements in environmental engineering and other aspects of engineering activity; makes attempts at understandably sharing such information and opinions, justifying different points of view.	**P7U_K**	**P7S_KK, P7S_KO, P7S_KR**	
K2_K07	acquires attention to the style of language and aesthetics of the work performed, including projects and reports	**P7U_K**	**P7S_KK, P7S_KO, P7S_KR**	

Attachment I

Specialisation: Mechanics of Materials (MM)

Specialisation learning outcomes	Description of learning outcomes for the specialisation	Reference to PRK characteristics		
		Universal first-degree characteristics (U)	Second-degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels PRK	Characteristics for qualifications on 7 levels PRK
KNOWLEDGE (W)				
K2S_MM_W01	possess advanced knowledge of mathematics in the area of functional analysis, differential equations, probability distributions and boundary problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W02	knows the general concept of forces (active and inertia); the principle of virtual work, freedom in the free vibration range and mechanical behaviour under dynamic problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W03	uunderstood the kinematic and dynamical phenomena responsible for various vehicle behaviour	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W04	possesses extended knowledge of contemporary design and construction techniques based on the Finite Element Method	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W05	possesses the extended knowledge on properties relationship as well as on strength engineering mechanisms in materials and their practical usage for material design of products	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W06	knows the fundamentals and design philosophy of modern engineering materials and introduces topics of composite materials and nanomaterials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W07	knows the mathematical framework and the computational techniques of uncertainty quantification, reliability analyses and optimisation problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W08	possesses comprehensive knowledge of the operation and maintains the reliability and safety of technical systems and the management of renewal processes.	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W09	knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**

K2S_MM_W10	possesses extended knowledge in microstructural laboratory techniques and know the principles of geometrical and pours media according to mechanical morphology of microstructure and nanostructure	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W11	knows the assumptions of manufacturing and applications of various materials; possess the knowledge of variability behaviour of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W12	knows and understand the principles of analytical and computational approaches in the framework of micromechanics of problems in elasticity	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W13	possesses a well-developed knowledge of the fundamentals of fracture mechanics, defect criticality assessment and estimation of the "life" of a structure, as well as cyclic loading behaviour	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W14	knows the general concept of designing materials for biological issues	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
K2S_MM_W15	possesses the knowledge of the welding process	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W16	knows the multidisciplinary concept of rheology and fluid mechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MM_W17	knows the concept of the designing process according to inventive engineering	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
SKILLS (U)				
K2S_MM_U01	possesses the ability to analyses and solve the mathematical problems in the area of functional analysis, the modal matrix for discrete linear systems and the virtual work principle	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U02	can apply advanced computational techniques, including simulation and dynamics analysis, compute the kinematics and dynamics groups of mechanisms	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U03	can estimate fundamental parameters of fracture mechanics and use experimental methods for fatigue lifetime predictions	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U04	possesses the ability to design the materials by chosen components of objects in the field of general construction problems and carry out research of components	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MM_U05	understand and use the advanced methods of studying the difference between the properties of nanomaterials and nanostructures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**

K2S_MM_U06	possesses the ability to solve tasks related to chosen theoretical issues to design process	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
COMPETENCES (K)				
K2S_MM_K01	can objectively evaluate the arguments and rationally explain and justify own point of view	**P7U_K**	**P7S_KK**	
K2S_MM_K02	possessing collaboration skills and able to lead the research teams in the engineering design process	**P7U_K**	**P7S_KK**	
K2S_MM_K03	possessing the skills of objective evaluation of arguments and formulation of rational conclusions concerning the use of engineering materials and processes	**P7U_K**	**P7S_KK**	
K2S_MM_K04	learn to think analytically, precisely formulate problems and solve them within a specific theory	**P7U_K**	**P7S_KK**	
K2S_MM_K05	can search for information and to critical review	**P7U_K**	**P7S_KK**	
K2S_MM_K06	understand aware of the necessity of needing the expanding knowledge	**P7U_K**	**P7S_KK**	
K2S_MM_K07	is aware of the necessity of verifying the computational approach used and the correctness of the results obtained.	**P7U_K**	**P7S_KK**	

Attachment I

Specialisation: Mechanics of Structure (MS)

Specialisation learning outcomes	Description of learning outcomes for the specialisation	Reference to PRK characteristics		
		Universal first-degree characteristics (U)	Second-degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels PRK	Characteristics for qualifications on 7 levels PRK
KNOWLEDGE (W)				
K2S_MS_W01	possess advanced knowledge of mathematics in the area of functional analysis, differential equations, probability distributions and boundary problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W02	knows the general concept of structure and mechanical behaviour under dynamic forces	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W03	possesses extended knowledge of contemporary design and construction techniques based on the Finite Element Method	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W04	know the principles of geometrical and pours media according to mechanical morphology of microstructure	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W05	get the introduction to topics of composite materials.	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W06	knows the mathematical framework and the computational techniques of uncertainty quantification, reliability analyses and optimisation problems	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W07	knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W08	possess developed knowledge in the mechanics of soil materials and geotechnical structure design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W09	possesses the knowledge for steel construction design	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W10	possess the knowledge of variability behaviour of materials	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W11	knows and understand the principles of analytical and computational approaches in the framework of micromechanics	**P7U_W**	**P7S_WG**	**P7S_WG_INZ**
K2S_MS_W12	possesses a well-developed knowledge of the fundamentals of fracture mechanics, defect criticality assessment and estimation of the "life" of a structure, as well as cyclic loading behaviour	**P7U_W**	**P7S_WK**	**P7S_WK_INZ**
SKILLS (U)				

K2S_MS_U01	possesses the ability to analyse and solve mathematical problems in the area of functional analysis, reliability analysis and optimisation problems	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U02	can apply advanced computational techniques, including optimisation ones, to model and calculate structures	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U03	can design chosen elements of geotechnical structures taking into consideration soil variability problems	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U04	can design and research components and materials	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U05	can design chosen components of objects concerning problems of general construction	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
K2S_MS_U06	can formulate and possesses the ability to solve tasks related to chosen theoretical issues to design process	**P7U_U**	**P7S_UW**	**P7S_UW_INZ**
COMPETENCES (K)				
K2S_MS_K01	can objectively evaluate the arguments and rationally explain and justify own point of view	**P7U_K**	**P7S_KK**	
K2S_MS_K02	possessing collaboration skills and able to lead the research teams in the engineering design process	**P7U_K**	**P7S_KK**	
K2S_MS_K03	possessing the skills of objective evaluation of arguments and formulation of rational conclusions concerning the use of engineering materials and processes	**P7U_K**	**P7S_KK**	
K2S_MS_K04	learn to think analytically, precisely formulate problems and solve them within a particular theory	**P7U_K**	**P7S_KK**	
K2S_MS_K05	can search for information and to critical review	**P7U_K**	**P7S_KK**	
K2S_MS_K06	understand aware of the need to expand the knowledge	**P7U_K**	**P7S_KK**	
K2S_MS_K07	is aware of the necessity of verifying the computational approach used and the correctness of the results obtained.	**P7U_K**	**P7S_KK**	

Zał. nr 3 do ZW 16/2020
Attachment no. 2. to the Program of Studies

DESCRIPTION OF THE PROGRAM OF STUDIES

FACULTY: Civil Engineering, Mechanical Engineering

MAIN FIELD OF STUDY: Advanced Solid Mechanics

EDUCATION LEVEL: ~~first-level (licencjat/inżynier) studies /~~ second-level studies ~~/ magister uniform studies*~~

FORM OF STUDIES: full-time studies ~~/ part-time studies *~~

PROFILE: general academic ~~/ practical *~~

SPECIALIZATION: Mechanics of Materials (MM), Mechanics of Structure (MS)

LANGUAGE OF STUDY: English

1. Opis ogólny

1.1. Number of semesters:	***4***
1.2. Total number of ECTS points necessary to complete studies at a given level:	***120***
1.3. Total number of hours:	
Mechanics of Materials (MM)	***1022***
Mechanics of Structure (MS)	***1022***

1.4. Prerequisites (particularly for second-level studies):

An applicant for second level studies in Advanced Solid Mechanics in the Wroclaw University of Science and Technology must have qualifications of first level studies in science or technical sciense with minimum 180 ECTS or an equivalent first academic degree from an internationally recognized university. An applicant should be competent in continuing education at second level studies in this faculty. Candidates applying for second level studies in Advanced Solid Mechanics must:

- possess knowledge from selected fields of mathematics and physics which enables the understanding of the physical basis of construction and also the formulation and solving of simple problems in the area of civil and mechanical engineering;

- possess knowledge from chemistry which enables the understanding of the basis of chemical properties of the materials used in civil and mechanical engineering;

- be able to read and understand architectural, constructional, geodesy, and mechanical drawings and make proper project documentation in a graphical environment on selected CAD software;

- possess knowledge and be competent in the area of structural mechanics and strength of materials;

- possess knowledge and ability to apply the principles of structural mechanics and bar construction analysis in the areas of statics, dynamics and stability;

- be able to apply appropriate computational models and carry out structural mechanic analysis and mechanical analyses of simple structures;

- possess skills in the area of interpretation, presentation and documentation of simple experiments and also in the area of presentation and documentation of the results of task implementation with project characteristics.

The principles for verifying the competencies of candidates are determined by the appropriate resolutions of the Faculty Council

1.5. Upon completion of studies graduate obtains professional degree of:	***magister inżynier***

1.6. Graduate profile, employability:

After finishing second level studies in the Advanced Solid Mechanics, a graduate, using his acquired knowledge and skills is ready to make decisions regarding the appropriate usage of materials, construction design and construction projects. Knows the current trends in the design and execution of building projects. Uses principles of occupational health and safety. Is able to design buildings, knows the principles of structural mechanics and is able to formulate, create, and then use the appropriate computational models of complex engineering structures. Can make and read technical drawings, recognize geodesy and cartography documentations and manage construction works. Is able to formulate and solve new engineering, technical and organizational issues related to civil and mechanical engineering. Can use modern computer aided technics in the design process. Can critically select arguments supporting collective decisions related to the execution of tasks in civil engineering. Is able to formulate and publish reports on the progress of carried out works. Is able to solve complex problems, including application of independent observation, measurement and modelling methods.

Is able to work in a team and supervise a team's duties. Is responsible for the safety of a supervised team. Is aware of the need to improve his professional and personal competence. Follows ethical rules. Knows and uses the principles of construction law.

Has language skills in the fields of science and scientific disciplines relevant to the studied faculty and requirements for B+ level of the Common European Framework of Reference for Languages. Is prepared to continue his education at third level studies. Graduates are able to: solve complex design, organizational and technological issues, formulate and carry out research programs, run projects of international scope, continue their education and participate in research and disciplines directly related to civil engineering and mechanical engineering, constantly update their qualifications and knowledge and also manage large groups of people. Graduates are qualified to take a job in: construction and design offices, executive enterprises, research institutes and development centres and also guidence institutions disseminating knowledge from civil and mechanical engeneering. Futhermore, graduates of each specialization achieve additional extended competence refering to the education outcomes of their specialization:

A graduate of Mechanics of Materials possesses enriched knowledge and advanced skills, including: the ability to analyses and solve the mathematical problems in the area of functional analysis, the modal matrix for discrete linear systems and the virtual work principle; applying advanced computational techniques, including simulation and dynamics analysis, compute the kinematics and dynamics groups of mechanisms; can estimate fundamental parameters of fracture mechanics and use experimental methods for fatigue lifetime predictions; possesses the ability to design the materials by chosen components of objects in the field of general construction problems and carry out research of components; understand and use the advanced methods of studying the difference between the properties of nanomaterials and nanostructures.

A graduate of Mechanics of Structures possesses enriched knowledge and advanced design skills, including: possesses the ability to analyse and solve mathematical problems in the area of functional analysis, reliability analysis and optimisation problems; can apply advanced computational techniques, including optimisation ones, to model and calculate structures; can design chosen elements of geotechnical structures taking into consideration soil variability problems; can design and research components and materials; can design chosen components of objects concerning problems of general construction; can formulate and possesses the ability to solve tasks related to chosen theoretical issues to design process.

1.7. Possibility of continuing studies: ***doctoral school***

1.8. Indicate connection with University's mission and its development strategy:

The Advanced Solid Mechanics on second level studies with specializations carried out during full-time studies: Mechanics of Structures and Mechanics of Materials; Civil Engineering (conducted in English) which is run according to the mission and development strategy of Wroclaw University of Science and Technology. Studies on the Civil Engineering Faculty and Mechanical Eginerring Facoulty are closely related to scientific and research works carried out at the Civil Engineering Facoulty and Mechanical Engineering Facoulty by the chairs and divisions.

2. Detailed description

2.1. The total number of learning outcomes in the program of study:

directional	*W (knowledge) =*	*U (skills) =*	*K (competences) =*	*W + U + K =*
	16	***14***	***7***	***37***
specialization				
Mechanics of Materials (MM	***17***	***6***	***7***	***30***
Mechanics of Structure (MS)	***12***	***6***	***7***	***25***

2.2. For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline:

D1 - Civil engineering and transport (major), (this number must be greater than half the total number of learning outcomes)	***31***
D2 - Mechanical engineering	***30***
D3 -	
D4 -	

2.3. For the field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline:

D1 - Civil engineering and transport (major)	*% points ECTS:*	***54.9%***
D2 - Mechanical engineering		***45.1%***
D3 -		
D4 -		

2.4a. For the general academic profile field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the faculty is assigned (must be greater than 50% of the total number of ECTS points from 2.1):	***120***
2.4b. For the practical profile field of study - the number of ECTS points assigned to the classes shaping practical skills (must be greater than 50% of the total number of ECTS points from 2.1):	-

2.5. Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market

The education program aims to comprehensively prepare highly qualified engineering technical staff in the widely considered field of civil engineering and mechanical engineering. Due to the flexibillity of mobility paths students have their autonomy in the developement of the learing process which is beneficial for their proffesional career. Universal basic knowledge enables graduates to flexibly adapt to the changing needs of the labour market. Each specialization (Mechanics of Structures and Mechanics of Materials) prepares graduates for research and science work, and gives graduates the opportunity to establish cooperation with international construction companies. The basis of all specializations is knowledge and skills which enable graduates to obtain appropriate professional qualifications.

2.6. The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students (enter the sum of ECTS points for courses / groups of courses marked with the BU1 code)	
Mechanics of Materials (MM	***45.6***

Mechanics of Structure (MS)	***45.4***
2.7. Total number of ECTS points which student has to obtain from basic sciences classes	
Number of ECTS points for obligatory subjects:	***10***
Number of ECTS points for optional subjects:	***0***
Total number of ECTS points:	***10***
2.8. Total number of ECTS points, which student has to obtain from practical classes, including project and laboratory classes (enter total number of ECTS points for courses/group of courses denoted with code P)	
Mechanics of Materials (MM	***61.6***
Mechanics of Structure (MS)	***61.8***
2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of university-wide classes or other main field of study (enter number of ECTS points for courses/groups of courses denoted with code O)	***-***
2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points):	***-***

4. List of education blocks

Definitions:

[1]BU – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students

[2]Traditional – T, distance – Z

[3]Exam – E, crediting with grade – Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)

[4]University-wide course /group of courses – O

[5] Course / group of courses Concerning scientific activities– DN

[6]Practical course / group of courses – P. For the group of courses (GK) - in brackets enter the number of ECTS points assigned to practical courses

[7]KO – general education, PD – basic sciences, K – field-of-studies, S – specialization

CNPS – total student's work; ZZU – organized courses; 1 ECTS = 30 hrs NPS

Note: the effects with the U code are obtained only during practical classes.

Advanced Solid Mechanics (ASM) - Blocks for:

Mechanics of Structure (MS)

Mechanics of Materials (MM)

4.1. List of obligatory blocks

4.1.2. List of basic science blocks

4.1.2.1. Block Mathematics (min. 5 ECTS)

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific activities[5]	practical P[6]	kind[7]	type
1		Mathematical Tools for Engineering	1.33333					K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	20	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.333					20	60	2	2	1	T, Z	Z	O	2	1.3	PD	Ob.
					0.667				10	30	1	1		T, Z	Z		1	0.7	PD	Ob.
		Total	1.33333	1.333	0.667	0	0		50	150	5	5	3				5	2		

4.1.2.2. Block Numerical Methods (min. 5 ECTS)

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific activities[5]	practical P[6]	kind[7]	type
1		Numerical Methods in Engineering	1.06667					K2_W02, K2_W07, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.067					16	30	1	1	1	T, Z	Z	O	1	0.6	PD	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	PD	Ob.
		Total	1.06667	1.067	0	1.2	0		50	150	5	5	3				5	1.3		

In total for obligatory basic science blocks:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
2.4	2.4	0.667	1.2	0	100	300	10	10	6.0

number of ECTS points P
3.3

4.1.3. List of main-field-of-study blocks

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific activities[5]	practical P[6]	kind[7]	type
1		Continuum Mechanics	1.06667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	3	T, Z	Z		2		K	Ob.
				1.6					24	60	2	2	2	T, Z	Z		2	1.3	K	Ob.
					0.533				8	30	1	1		T, Z	Z		1	0.7	K	Ob.
2		Constitutive Laws	1.46667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W05, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	22	60	2	2	2	T, Z	Z		2		K	Ob.
				1.2					18	60	2	2	2	T, Z	Z		2	0.4	K	Ob.
						0.667			10	30	1	1		T, Z	Z		1	0.7	K	Ob.
3		Dynamics and Vibrations	1.06667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W06, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	30	1	1	2	T, Z	Z		1		K	Ob.
				0.933					14	60	2	2	1	T, Z	Z		2	0.7	K	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	K	Ob.
4		Experimental Mechanics	0.8					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	12	30	1	1	1	T, Z	Z		1		K	Ob.
				0.533					8	30	1	1	1	T, Z	Z		1	1	K	Ob.
					0.8				12	60	2	2	1	T, Z	Z		2	1.3	K	Ob.
						1.6			24	30	1	1	1	T, Z	Z		1	0.7	K	Ob.
5	**ASB000152**	Functional Analysis - Applications To Boundary Value Problems (CE) Analiza funkcjonalna – zastosowania do problemów wartości brzegowych	2					K2_W01, K2_W03, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	E		3		K	Ob.
				2					30	60	2	2	0.6	T, Z	Z		2	1	K	Ob.
6	**ASM003002**	Analytical Mechanics (ME) Mechanika Analityczna	2					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	30	60	2	2	0.6	T, Z	E		2		K	Ob.
				1					15	30	1	1	0.7	T, Z	Z		1	2	K	Ob.
					1				15	60	2	2	0.6		Z		2	2	K	Ob.
7	**ASM003000**	Modeling of Multibody Systems (ME) Modelowanie układów wielczłonowych				4		K2_W02, K2_W04, K2_W06, K2_W07, K2_W08, K2_W13, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	60	150	5	5	1.4	T, Z	Z		5	3	K	Ob.
8	**ASM003003**	Design of Engineering Materials (ME) Projektowanie Materiałów Inżynierskich	2					K2_W01, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
						2			30	60	2	2	0.7	T, Z	Z		2	1	K	Ob.
9	**ASB000252**	Probabilistic Methods in Engineering (CE) Metody probabilistyczne w inżynierii	2					K2_W01, K2_W02, K2_W03, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	K	Ob.
							1		15	30	1	1	0.6	T, Z	Z		1		K	Ob.

10	**ASB000352**	Artificial Intelligence in Engineering (CE) Sztuczna inteligencja w inżynierii	2					K2_W02, K2_W07, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	2	K	Ob.
		Total	14.4	8.267	4.333	9.467	1		562	1500	50	50	25				50	19.5		

4.1.4. List of specialization blocks

Specializati Mechanics of Structure (MS)

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific activities[5]	practical P[6]	kind[7]	type
1	**ASB030553**	Risk Assessment in Geotechnics - Implementation of Random Field Theory (CE) Ocena ryzyka w geotechnice – zastosowania teorii pól losowych	3					K2_W01, K2_W02, K2_W03, K2_W07, K2_W09, K2_W10, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W06, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	45	90	3	3	0.6	T, Z	Z		3		S	Ob.
					1				15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
2	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
3	**ASB030653**	Advanced Geoengineering (CE) Zaawansowana Geoinżynieria	2					K2_W04, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W02, K2S_MS_W03, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	30	1	1	0.6	T, Z	Z		1		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
							1		15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.

5	**ASB030753**	Advanced Steel-Concrete Composite Constructions (CE) Zaawansowane konstrukcje zespolone stalowo-betonowe	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W02, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W09, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
						2		30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
6	**ASB030853**	Advanced Soil Mechanics and Soil Structure Interaction (CE) Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W09, K2_W10, K2_W11, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
7	**ASB029954**	Master thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Total	13	1	6	1	3		360	1800	60	60	14.8				60	38.8		

Specializati Mechanics of Materials (MM)

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific activities[5]	practical P[6]	kind[7]	type
1	**ASB020553**	Laboratory Identification of Composite Microstructure Properties (CE) Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów	1					K2_W02, K2_W03, K2_W04, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W14, K2S_MM_W16, K2S_MM_U03, K2S_MM_U04, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	30	1	2	0.6	T, Z	Z		2		S	Ob.
					2				30	90	3	3	1	T, Z	Z		3	2	S	Ob.
							1		15	30	1			T, Z	Z				S	Ob.
2	**ASM003001**	Advanced Nano-Materials (ME) Zaawansowane nanomateriały	2					K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W17, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_U04, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3		T, Z	Z		3		S	Ob.
					2				30	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
						2			30	30	1	1	0.6				1	1	S	
3	**ASM003007**	Reliability and Maintenance Theory and Engineering (ME) Teoria i inżynieria niezawodności i eksploatacji	2					K2_W01, K2_W03, K2_W09, K2_W10, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W07, K2S_MM_W08, K2S_MM_W09, K2S_MM_U03, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
5	**ASM003005**	Inventive Engineering (ME) Inżynieria wynalazczości	2					K2_W02, K2_W07, K2_W11, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02,	30	60	2	2		T, Z	Z		2		S	Ob.

						1		K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W17, K2S_MM_U02, K2S_MM_U03, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	90	3	3	0.6	T, Z	Z		3	1	S	Ob.
6	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
7	**ASB029954**	Master thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Total	11	1	7	4	1		360	1800	60	60	14.6				60	39		

4.3. Training block - concerning principles of training crediting

not applicable	**-**

4.4. Diploma dissertation block (Faculty Council Resolution on regulations on final thesis and thesis exam
KSIĘGA PROCEDUR na Wydziale Budownictwa Lądowego i Wodnego Politechniki Wrocławskiej. Procedura dyplomowania Pr 8/4. Zatwierdzona przez Dziekana Wydziału BLiW PWr w dniu 22.09.2020

Type of diploma dissertation	**Master**	
Number of diploma dissertation semesters	**Number of ECTS points**	**Code**
1	**30**	**ASB029954**
Character of diploma dissertation		
Master Thesis carried out at the second level studies can be a study, study and design or experimental and design one. It should demonstrate a graduate skills acquired during the studies, its scope should not go beyond the issues included in the programme of courses, both of the main field and specialization ones, with regard to the matters contained in the learning outcomes for the 1st level studies.		
Number of BK[1] ECTS points	**0.3**	

5. Ways of verifying assumed educational effects

Type of classes	**Ways of verifying assumed educational effects**
lecture	e.g. examination, progress/final test
class	e.g. progress, final test, presentation
laboratory	e.g. pretest, report from laboratory, presentation
project	e.g. report, project defence
seminar	e.g. participation in discussion, topic presentation, essay
training	e.g. report from training
diploma dissertation	prepared diploma dissertation, defence, examination

6. Range of diploma dissertation

General rules for the organization and conduct of the final diploma exam is specified in § 25 of the Regulations of higher education at the Wrocław University of Science and Technology.

The exam consists of two parts:
a) presentation of master thesis subject, methods used for its realization and the results obtained; the defense of the thesis by providing the student answers (oral or drawing) on oral questions of the Diploma Examinations Commission members asked during or immediately after the presentation of the work; questions must only touch the thesis content and the applied methodology;
b) an oral examination in the field of core and specialization subjects with the aim to review the student's knowledge in a range specified in the curriculum of the specialization of the second-degree. The student is asked at least three questions, two of which concerning major subjects and at least one must refer the subjects of specialization. The curriculum for each specialization is placed on the website of the Faculty. The exam cannot contain questions of the issues that were not in the program of study being completed by the student

7. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular blocks

According to the Regulations of higher education at the Wrocław University of Science and Technology.

8. Study plan (attachment no. 3)

Approved by the relevant legislative body of the Student Government:

....

Data Name, surname and signature of the student representative

....

Data Signature of the Dean of the Faculty / Director of the Branch

Zał. nr 4 do ZW 16/2020
Attachment no. 3 to Program of Studies

PLAN OF STUDIES

FACULTY: Civil Engineering, Mechanical Engineering

MAIN FIELD OF STUDY: Advanced Solid Mechanics

EDUCATION LEVEL: ~~first-level (licencjat/inżynier) studies /~~ second-level studies ~~/ magister uniform studies*~~

FORM OF STUDIES: full-time studies ~~/ part-time studies *~~

PROFILE: general academic ~~/ practical *~~

SPECIALIZATION: Mechanics of Materials (MM), Mechanics of Structure (MS)

LANGUAGE OF STUDY: English

In effect since 1.10.2021

*delete as applicable

1. **Set of obligatory and optional courses and groups of courses in semesteral arrangement**

Definitions:

[1]BU – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students

[2]Traditional – T, distance – Z

[3]Exam – E, crediting with grade – Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)

[4]University-wide course /group of courses – O

[5] Course / group of courses Concerning scientific activities– DN

[6]Practical course / group of courses – P. For the group of courses (GK) - in brackets enter the number of ECTS points assigned to practical courses

[7]KO – general education, PD – basic sciences, K – field-of-studies, S – specialization

CNPS – total student's work; ZZU – organized courses; 1 ECTS = 30 hrs NPS

Note: the effects with the U code are obtained only during practical classes.

Advanced Solid Mechanics (ASM) - Blocks for:

Mechanics of Structure (MS)

Mechanics of Materials (MM)

Semester 1 * HOURS CONVERSED TO A 15 WEEKS SYSTEM

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1		Mathematical Tools for Engineering	1.3333					K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	20	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.333					20	60	2	2	1	T, Z	Z	O	2	1.3	PD	Ob.
					0.667				10	30	1	1		T, Z	Z		1	0.7	PD	Ob.
2		Numerical Methods in Engineering	1.0667					K2_W02, K2_W07, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	2	T, Z	Z	O	2		PD	Ob.
				1.067					16	30	1	1	1	T, Z	Z	O	1	0.6	PD	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	PD	Ob.
3		Continuum Mechanics	1.0667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	60	2	2	3	T, Z	Z		2		K	Ob.
				1.6					24	60	2	2	2	T, Z	Z		2	1.3	K	Ob.
					0.533				8	30	1	1		T, Z	Z		1	0.7	K	Ob.
4		Constitutive Laws	1.4667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W05, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	22	60	2	2	2	T, Z	Z		2		K	Ob.
				1.2					18	60	2	2	2	T, Z	Z		2	0.4	K	Ob.
						0.667			10	30	1	1		T, Z	Z		1	0.7	K	Ob.
5		Dynamics and Vibrations	1.0667					K2_W01, K2_W02, K2_W03, K2_W04, K2_W06, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	16	30	1	1	2	T, Z	Z		1		K	Ob.
				0.933					14	60	2	2	1	T, Z	Z		2	0.7	K	Ob.
						1.2			18	60	2	2		T, Z	Z		2	0.7	K	Ob.
6		Experimental Mechanics	0.8					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	12	30	1	1	1	T, Z	Z		1		K	Ob.
				0.533					8	30	1	1	1	T, Z	Z		1	1	K	Ob.
					0.8				12	60	2	2	1	T, Z	Z		2	1.3	K	Ob.
						1.6			24	30	1	1	1	T, Z	Z		1	0.7	K	Ob.
		Total	6.8	6.667	2	4.667	0		302	900	30	30	22				30	10.8		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
6.8	6.667	2	4.667	0	302	900	30	30	22

number of ECTS points P
10.8

Semester 2

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1	**ASB000152**	Functional Analysis - Applications To Boundary Value Problems (CE) Analiza funkcjonalna – zastosowania do problemów wartości brzegowych	2					K2_W01, K2_W03, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	E		3		K	Ob.
				2					30	60	2	2	0.6	T, Z	Z		2	1	K	Ob.
2	**ASM003002**	Analytical Mechanics (ME) Mechanika Analityczna	2					K2_W01, K2_W03, K2_W04, K2_W05, K2_W06, K2_W08, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06	30	60	2	2	0.6	T, Z	E		2		K	Ob.
				1					15	30	1	1	0.7	T, Z	Z		1	2	K	Ob.
					1				15	60	2	2	0.6		Z		2	2	K	Ob.
3	**ASM003006**	Modeling of Multibody Systems (ME) Modelowanie układów wielczłonowych				4		K2_W02, K2_W04, K2_W06, K2_W07, K2_W08, K2_W13, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	60	150	5	5	1.4	T, Z	Z		5	3	K	Ob.
4	**ASM003003**	Design of Engineering Materials (ME) Projektowanie Materiałów Inżynierskich	2					K2_W01, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
						2			30	60	2	2	0.7	T, Z	Z		2	1	K	Ob.
5	**ASB000252**	Probabilistic Methods in Engineering (CE) Metody probabilistyczne w inżynierii	2					K2_W01, K2_W02, K2_W03, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	K	Ob.
							1		15	30	1	1	0.6	T, Z	Z		1		K	Ob.
6	**ASB000352**	Artificial Intelligence in Engineering (CE) Sztuczna inteligencja w inżynierii	2					K2_W02, K2_W07, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07	30	90	3	3	0.6	T, Z	Z		3		K	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	2	K	Ob.
		Total	10	4	3	6	1		360	900	30	30	8.8				30	12.0		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
10	4	3	6	1	360	900	30	30	8.8

number of ECTS points P
12.0

Total accumulated:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
16.8	10.67	5	10.67	1	662	1800	60	60	30.8

number of ECTS points P
22.8

Specialization: Mechanics of Structure (MS)

Semester 3

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1	**ASB030553**	Risk Assessment in Geotechnics - Implementation of Random Field Theory (CE) Ocena ryzyka w geotechnice – zastosowania teorii pól losowych	3					K2_W01, K2_W02, K2_W03, K2_W07, K2_W09, K2_W10, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W06, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	45	90	3	3	0.6	T, Z	Z		3		S	Ob.
					1				15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
2	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
3	**ASB030653**	Advanced Geoengineering (CE) Zaawansowana Geoinżynieria	2					K2_W04, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W02, K2S_MS_W03, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	30	1	1	0.6	T, Z	Z		1		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
							1		15	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.

5	**ASB030753**	Advanced Steel-Concrete Composite Constructions (CE) Zaawansowane konstrukcje zespolone stalowo-betonowe	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W09, K2_W10, K2_W11, K2_W12, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W02, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W09, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
							2		30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
6	**ASB030853**	Advanced Soil Mechanics and Soil Structure Interaction (CE) Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem	2					K2_W02, K2_W03, K2_W04, K2_W05, K2_W07, K2_W09, K2_W10, K2_W11, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W08, K2S_MS_W10, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1.2	S	Ob.
		Total	13	1	6	1	3		360	900	30	30	7.8				30	8.8		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]	number of ECTS points P
lec	cl	lab	pr	sem						
13	1	6	1	3	360	900	30	30	7.8	8.8

Total accumulated:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]	number of ECTS points P
lec	cl	lab	pr	sem						
29.8	11.67	11	11.67	4	1022	2700	90	90	38.6	31.6

Semester 4

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1	**ASB029954**	Master Thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Total	0	0	0	0	0		0	900	30	30	7				30	30		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
0	0	0	0	0	0	900	30	30	7.0

number of ECTS points P
30.0

Total accumulated:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
29.8	11.67	11	11.67	4	1022	3600	120	120	45.6

number of ECTS points P
61.6

Total number of ZZU hours: **1022**

Hours - lectures: **43.7%**

Hours - other courses: **56.3%**

ECTS - BU: **38.0%**

ECTS - P: **51.3%**

Specialization: Mechanics of Materials (MM)

Semester 3

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1	**ASB020553**	Laboratory Identification of Composite Microstructure Properties (CE) Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów	1					K2_W02, K2_W03, K2_W04, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W14, K2S_MM_W16, K2S_MM_U03, K2S_MM_U04, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	15	30	1	2	0.6	T, Z	Z		2		S	Ob.
					2				30	90	3	3	1	T, Z	Z		3	2	S	Ob.
							1		15	30	1			T, Z	Z				S	Ob.
2	**ASM003001**	Advanced Nano-Materials (ME) Zaawansowane nanomateriały	2					K2_W03, K2_W04, K2_W05, K2_W07, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W17, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_U04, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3		T, Z	Z		3		S	Ob.
					2				30	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
						2			30	30	1	1	0.6				1	1	S	
3	**ASM003007**	Reliability and Maintenance Theory and Engineering (ME) Teoria i inżynieria niezawodności i eksploatacji	2					K2_W01, K2_W03, K2_W09, K2_W10, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W07, K2S_MM_W08, K2S_MM_W09, K2S_MM_U03, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
						1			15	60	2	2	0.6	T, Z	Z		2	1	S	Ob.

4	**ASM003004**	Fracture Mechanics (ME) Mechanika Pękania	2					K2_W01, K2_W02, K2_W03, K2_W04, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W03, K2S_MS_W04, K2S_MS_W09, K2S_MS_W10, K2S_MS_W12, K2S_MS_U01, K2S_MS_U02, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W02, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W13, K2S_MM_W16, K2S_MM_U01, K2S_MM_U02, K2S_MM_U03, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	E		3		S	Ob.
				1					15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
					1				15	30	1	1	0.6	T, Z	Z		1	1	S	Ob.
5	**ASM003005**	Inventive Engineering (ME) Inżynieria wynalazczości	2					K2_W02, K2_W07, K2_W11, K2_W13, K2_W14, K2_W15, K2_W16, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U09, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W17, K2S_MM_U02, K2S_MM_U03, K2S_MM_U05, K2S_MM_U06, K2S_MM_K01, K2S_MM_K02, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	60	2	2		T, Z	Z		2		S	Ob.
						1			15	90	3	3	0.6	T, Z	Z		3	1	S	Ob.
6	**ASB000453**	Mathematical Homogenizations and Micromechanics (CE) Matematyczna homogenizacja i mikromechanika	2					K2_W01, K2_W02, K2_W04, K2_W05, K2_W08, K2_W11, K2_W13, K2_W14, K2_W15, K2_U01, K2_U02, K2_U03, K2_U04, K2_U05, K2_U06, K2_U07, K2_U08, K2_U10, K2_U11, K2_U12, K2_U13, K2_U14, K2_K01, K2_K02, K2_K03, K2_K04, K2_K05, K2_K06, K2_K07, K2S_MS_W01, K2S_MS_W03, K2S_MS_W04, K2S_MS_W05, K2S_MS_W10, K2S_MS_W11, K2S_MS_U01, K2S_MS_U02, K2S_MS_U03, K2S_MS_U04, K2S_MS_U05, K2S_MS_U06, K2S_MS_K01, K2S_MS_K02, K2S_MS_K03, K2S_MS_K04, K2S_MS_K05, K2S_MS_K06, K2S_MS_K07, K2S_MM_W01, K2S_MM_W04, K2S_MM_W05, K2S_MM_W06, K2S_MM_W10, K2S_MM_W11, K2S_MM_W12, K2S_MM_W14, K2S_MM_W16, K2S_MM_U01, K2S_MM_U04, K2S_MM_U05, K2S_MM_K01, K2S_MM_K02, K2S_MM_K03, K2S_MM_K04, K2S_MM_K05, K2S_MM_K06, K2S_MM_K07	30	90	3	3	0.6	T, Z	Z		3		S	Ob.
					2				30	60	2	2	0.6	T, Z	Z		2	1	S	Ob.
		Total	11	1	7	4	1		360	900	30	30	7.6				30	9.0		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
11	1	7	4	1	360	900	30	30	7.6

number of ECTS points P
9.0

Total accumulated:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
27.8	11.67	12	14.67	2	1022	2700	90	90	38.4

number of ECTS points P
31.8

Semester 4

Obligatory courses **number of ECTS points 30**

No.	Course / group of courses code	Name of course / group of courses (denote group of courses with symbol GK)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of course / group of courses	Way[3] of crediting	Course/group of courses				
			lec	cl	lab	pr	sem		ZZU	CNPS	total	DN[5] classes	BU[1] classes			university-wide[4]	Concerning scientific	practical P[6]	kind[7]	type
1	**ASB029954**	Master Thesis (MSc)								900	30	30	7	T, Z	Z		30	30.0	S	Ob.
		Total	0	0	0	0	0		0	900	30	30	7				30	30		

Total in semester:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
0	0	0	0	0	0	900	30	30	7.0

number of ECTS points P
30.0

Total accumulated:

Total number of hours					Total number of hours ZZU	Total number of hours CNPS	Total number of ECTS points	Total number of ECTS points DN[5]	number of ECTS points BU[1]
lec	cl	lab	pr	sem					
27.8	11.67	12	14.67	2	1022	3600	120	120	45.4

number of ECTS points P
61.8

Total number of ZZU hours: **1022**

Hours - lectures: **40.8%**

Hours - other courses: **59.2%**

ECTS - BU: **37.8%**

ECTS - P: **51.5%**

2. Set of examinations in semestral arrangement

No	Course code	Names of courses ending with examination	Semester
1	ASB000152	Functional Analysis - Applications To Boundary Value Problems (CE)	2
2	ASM003002	Analytical Mechanics (ME)	2
3	ASM003004	Fracture Mechanics (ME)	3
4	ASB030753	Advanced Steel-Concrete Composite Constructions (CE)	3
5	ASB030853	Advanced Soil Mechanics and Soil Structure Interaction (CE)	3

3. Numbers of allowable deficit of ECTS points after particular semesters

Semester	Allowable deficit of ECTS points after semester	Total number of points required for registration for the next semester
1	15	15
2	13	47

Opinion of the faculty student government legislative body:

Date Name and surname, signature of the student representative

Date Signature of the Dean of the Faculty / Director of the Branch

COURSE CATALOGUE

SUBJECT FORMS

FACULTY: **Civil Engineering, Mechanical Engineering**

MAIN FIELD OF STUDY: **Advanced Solid Mechanics**

in area of technical science

EDUCATION LEVEL: ~~1st /~~ 2nd * level, ~~licencjat / inżynier / magister~~ ~~/~~ magister inżynier (MSc) studies*

FORM OF STUDIES: full-time ~~/ part-time~~*

PROFILE: general academic ~~/ practical~~ *

LANGUAGE OF STUDY: English

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Analiza funkcjonalna – zastosowania do problemów wartości brzegowych**
Name of subject in English:	**Functional analysis – applications to boundary value problems**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~ **/ 2nd level**~~, uniform magister~~ **studies*, full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory /** ~~optional / university-wide~~*****
Subject code:	**ASB000152**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**	**30**			
Number of hours of total student workload (CNPS)	**90**	**60**			
Form of crediting	**Examination** ~~/ crediting with grade *~~	~~Examination~~ **/ crediting with grade***	Examination~~./~~ crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**	**2**			
including number of ECTS points for practical (P) classes		**1**			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**	**0.6**			

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Elementary course in calculus
2. Basic knowledge in ordinary differential equation

SUBJECT OBJECTIVES

C1. Introducing elements of the theory of boundary value problems
C2. Familiarizing students with basing notions of functional analysis
C3. Demonstrating the mathematical basis of numerical solutions of boundary value problems

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Learn the basics of the theory of partial differential equations PEU_W02 Learn the contemporary methods of solving boundary problems PEU_W03 Learn the basics of functional analysis relating to skills: PEU_U01 Correctly distinguishes between types of differential equations and boundary problems PEU_U02 Knows the basics of distributive differentiation PEU_U03 Gains skills in formulating and solving numerically complex boundary problems PEU_U04 Is aware of the importance of the assumptions made PEU_U05 Knows the mathematical bases of the finite element method (FEM) and the boundary element method (BEM) PEU_U06 Is able to recognize the concept of metric spaces theory in various engineering problems. PEU_U07 Understands the weak formulation and variational formulation relating to social competences: PEU_K01 Learns to think analytically, precisely formulate problems and solve them within a certain theory and with specific assumptions PEU_K02 Can work on solving problems in a team

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	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.	4
Lec2	The Laplace equation. Harmonic functions	2
Lec3	Metrix spaces: examples, convergence in metric spaces, complete metric spaces, the Banach fixed-point theorem.	2
Lec4	Normed spaces, Banach spaces, Linear operators and functionals, bounded operators (Banach's theorem).	4
Lec5	Unitary spaces and their geometrical properties (Pythagorean theorem), Hilbert spaces, orthogonal expansions, the orthogonal projection theorem. Continuous linear functionals in Hilbert spaces – the Riesz theorem.	6
Lec6	Sobolev spaces. Functions of compact support, distributions, distribution derivatives, properties of H1 and H2 spaces.	6
Lec7	Generalized solutions of elliptic equations. Weak formulation of boundary value problems, the Lax-Milgram theorem, applications of the Lax-Milgram theorem.	2
Lec8	Methods of solving of variational equations. The method of least squares, the orthogonal projection method, the Galerkin method, the Ritz method.	2
Lec9	Basis of finite element method	2
	Total hours	**30**

Classes	**Number of hours**

Cl1	Simplest methods of integrating partial differential equations.	1
Cl2	Reducing linear partial differential equation of the second order to canonical forms. Applications to solving boundary value problems.	4
Cl3	Solving boundary value problems by means variable separation method.	2
Cl4	Solving boundary value problems of the elliptic type.	2
Cl5	Solving problems dealing with distances in various metric spaces. Finding geometry of open and closed balls in various metric spaces.	2
Cl6	Applications of Banach's fixed point theorem.	2
Cl6	Solving problems dealing with normed and Banach spaces.	3
Cl7	Solving problem concerning bounded linear operators and bounded linear functionals.	2
Cl8	Problems on scalar product properties and geometry of unitary spaces.	3
Cl9	Approximation of various functions by using the orthogonal projection theorem.	2
Cl10	Solving problems on distributions and their derivatives.	3
Cl11	Applications of the Lax-Millgram theorem.	2
Cl12	Solving problems on applications of the Galerkin method and the Ritz method. Kolokwium zaliczające ćwiczenia (45 minut)	2
	Total hours	**30**

Laboratory		**Number of hours**
Lab1	**Not applicable**	
	Total hours	

Project		**Number of hours**
Proj1	**Not applicable**	
	Total hours	

Seminar		**Number of hours**
Sem1	**Not applicable**	
	Total hours	

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation	Learning	Way of evaluating learning outcomes

F – forming (during semester), P –concluding (at semester end)	outcomes number	achievement
F1(lecture)	PEU_W01 PEU_W02 PEU_W03	Written exam
F2 (Classes)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_U05 PEU_U06 PEU_U07	Test
P = 0.7*F1 + 0.3*F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R.V. Churchill, J.W.Brown, Fourier Series and Boundary Value Problems, McGraw-Hill Book Company, New York 1978.

[2] K. Yosida, Functional Analysis, Springer 1995.

[3] D. Farenick, Fundamentals fo Functional Analysis, Springer, 2016.

SECONDARY LITERATURE:

[4] J.T. Odden and J.N. Reddy, An Introduction to Mathematical Theory of Finite Elements, J. Wiley & Sons, 1976.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

Prof. dr hab. inż. Wojciech Puła, W2/K09, Wojciech.pula@pwr.edu.pl

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Metody probabilistyczne w inżynierii**
Name of subject in English:	**Probabilistic methods in engineering**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASB000252**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**	**15**			**15**
Number of hours of total student workload (CNPS)	**90**	**30**			**30**
Form of crediting	~~Examination~~ **/ crediting with grade***	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	Examination / crediting with grade *	~~Examination~~ **/ crediting with grade ***
For group of courses mark (X) final course					
Number of ECTS points	**3**	**1**			**1**
including number of ECTS points for practical (P) classes		**1**			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**	**0.6**			**0.6**

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES
1. A basic course in calculus. 2. A basic course in mechanics.

SUBJECT OBJECTIVES
C1. To familiarized students with most important probabilistic tools. C2. To enable students to use probabilistic methods in their future work.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Learn about probability concept including modern approach based on measure theory. PEU_W02 Learn basics of random variables and random processes. PEU_W03 Learn to use statistical tools in conjunction with probability theory. PEU_W04 Learn to build probabilistic models for engineering use. relating to skills: PEU_U01 Is able to correctly understand basic notions within discrete and continuous probability theory PEU_U02 Knows evaluate probabilities and compute statistical moments of random variables PEU_U03 Is able to formulate simple statistical models regarding engineering problems PEU_U04 Is able to test various statistical various hypotheses PEU_U05 Can use reliability approaches in a design process relating to social competences: PEU_K01 Learn to work in a team PEU_K02 Is aware of the need to expand knowledge of modern techniques in engineering problems

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Basic discrete probability theory.	1
Lec 2	Some basic concepts of probability based theory of measure.	2
Lec 3	Random variables, probability distributions, expected value, variance, moments of higher order. Random vectors, stochastic independence, covariance/correlation.	3
Lec 4	Common discrete and continuous distributions.	2
Lec 5	Multidimensional distributions.	2
Lec 6	Convergence of probability distributions. Limit theorems.	2
Lec 7	Random processes – basic facts.	3
Lec 8	Stationary random processes – correlation theory.	2
Lec 9	Probabilistic modelling of engineering problems – examples.	2
Lec 10	Estimation theory. Confidence intervals.	2
Lec 11	Testing of statistical hypothesis.	2
Lec 12	Bayesian approaches	2
Lec 13	Basic concept of decision theory.	2
Lec14	Structural reliability concepts.	3
	Total hours	**30**

Classes		Number of hours
Cl1	Solving simple problems on discrete probability.	1
Cl2	Solving problems on probability evaluations, computing statistical	4

	moments for both discrete and continuous case.	
Cl3	Solving problems dealing with multivariate normal distributions.	2
Cl4	Applications of limit theorems.	2
Cl5	Solving problems on correlation structure of random processes.	2
Cl6	Simple modelling of engineering problems. Randomization.	2
Cl7	Carrying out of simple statistical tests.	2
	Total hours	**15**

Laboratory		**Number of hours**
Lab 2	**Not applicable**	
	Total hours	

Project		**Number of hours**
Proj1	**Not applicable**	
	Total hours	

Seminar		**Number of hours**
Sem1	Probabilistic modeling of material properties.	2
Sem2	Probabilistic modelling of loads in civil engineering.	2
Sem3	Selected problems of stochastic dynamics.	4
Sem4	Kriging.	2
Sem5	Applications of reliability theory.	3
Sem6	Reliability based design.	2
	Total hours	**15**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement

F1(Lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04	Written exam
F2 (Classes)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_U05	Test
F5 (Seminar)	PEU_W04	Presentation
P = 0.6*F1 + 0.3*F2 + 0.1*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] FISZ M. (1980), *Probability theory and mathematical statistics*. Krieger Publ. Co.
[2] CHUNG K.L. (1974). *A course in Probability Theory.* Academic Press, New York.
[3] BENJAMIN J.R, CORNELL C.A. (2014). *Probability, Statistics, and Decision for Civil Engineers,* Dover Publications.

SECONDARY LITERATURE:

[1] FELLER W., *An Introduction to Probability Theory and its Applications,* vol.1 , vol. 2, J. Wiley and Sons.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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Zał. nr 5 do ZW 16/2020

FACULTY OF ADVANCE SOLID MECHANICS

SUBJECT CARD

Name of subject in Polish:	**Sztuczna inteligencja w inżynierii**
Name of subject in English:	**Artificial intelligence in engineering**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level**~~, uniform magister~~ **studies*, full-time** ~~/ part-time studies*~~
Kind of subject:	**obligatory /** ~~optional~~ **/** ~~university-wide~~*****
Subject code:	**ASB000352**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**		**30**		
Number of hours of total student workload (CNPS)	**90**		**60**		
Form of crediting	~~Examination~~ **/ crediting with grade***		~~Examination~~**/ crediting with grade** *		
For group of courses mark (X) final course					
Number of ECTS points	**3**		**2**		
including number of ECTS points for practical (P) classes			**2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0,6**		**0,6**		

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES
1. Basic knowledge in civil engineering – types of structures and processes
2. Skill in application of basic computer techniques

SUBJECT OBJECTIVES
C1. Learning the fundamental techniques used in computer tools with elements of artificial intelligence – applied in civil engineering
C2. Development of ability to design, computer implementation and testing of simple expert tools with elements of artificial intelligence

SUBJECT LEARNING OUTCOMES	
Relating to knowledge:	
PEU_W01	The student knows and understands methods of knowledge acquisition and representation in expert systems
PEU_W02	The student knows methodology of design, computer implementation and testing of knowledge-based expert systems with elements of artificial intelligence
Relating to skills:	
PEU_U01	The student has skill to independent acquisition of knowledge in civil engineering
PEU_U02	The student has skill to design, computer implementation and testing of simple expert tools with elements of artificial intelligence, supporting decisions in civil engineering
Relating to social competences:	
PEU_K01	The student is able to unaided solving the problems and is also prepared to a team-work (laboratory reports, laboratory exercises)

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to the lectures: aims, scope and plan of the course. Basic literature and examination rules.	2
Lec2	Artificial intelligence (AI) – what is this? Basic terms and definitions. Short history of development.	2
Lec3	Artificial intelligence in engineering and society. Artificial Intelligence Engineer. Main fields of applications. Examples.	2
Lec4	Artificial intelligence in expert systems – classification, architecture, evolution, directions of development. Expert systems and range of their application in engineering.	2
Lec5	Technologies of knowledge acquisition and representation in computer systems. Knowledge bases and data bases. Knowledge Engineer in knowledge acquisition process.	2
Lec6	Artificial neural networks (ANN) – inspiration and conception, development history. ANN architecture, training and testing techniques, validation criteria.	2
Lec7	Applications of artificial neural networks in engineering. Modelling, pattern recognition, classification, forecasting, estimation.	2
Lec8	Fuzzy logic – fuzzy problems, linguistic variables, fuzzy reasoning procedures, basic operators, testing and validation.	2
Lec9	Fuzzy logic – development history and examples of applications in engineering.	2
Lec10	Genetic algorithms – inspiration, conception, basic operators. Applications of evolutionary algorithms in optimization and search problems. Heuristic function and procedure.	2
Lec11	Expert and intelligent systems applied in engineering. Expert systems based on knowledge – design and implementation procedures.	2
Lec12	Technology of hybrid networks in intelligent systems – conception, components, design and creation procedures, testing and validation.	2
Lec13	Artificial intelligence applications in engineering – expert tools supporting structure analysis and infrastructure management.	2
Lec14	Future of AI. Artificial Intelligence and autonomous intelligent systems – directions of development. Opportunities and risks.	2
Lec15	Colloquium	2
	Total hours	**30**

Classes	Number of hours

Cl1		
...		
	Total hours	

Laboratory		**Number of hours**
Lab1	Introductory classes. Presentation of the rules for passing the course. Discussing the idea of example projects	2
Lab2	Introduction to artificial intelligence. Theoretical and practical foundations necessary to perform first exercise	2
Lab3	Presentation of the program for building neural networks and learning how to use it.	2
Lab4	Overview of the concept of the first exercise. Data collection	2
Lab5	Implementation of a neural network solving the given problem	2
Lab6	Checking, testing and evaluating the neural network No. 1. Discussion of the content of the first report .	2
Lab7	Overview of the concept of the second exercise. Theoretical foundations necessary to perform second exercise	2
Lab8	Development of a concept for solving the problem of exercise 2.	2
Lab9	Preparation of data and neural network architecture	2
Lab10	Implementation of a neural network solving the given problem	2
Lab11	Checking, testing and evaluating the neural network No. 2. Discussion of the content of the second report .	2
Lab12	Discussion of the concept of the third exercise. Theoretical foundations necessary to perform third exercise 3	2
Lab13	Development of a problem solution concept. Data collection and implementation of a neural network	2
Lab14	Checking, testing and evaluating the neural network No. 3. Overview of the content of the third report	2
Lab15	Completion of the course. Entering grades.	2
	Total hours	**30**

Project		**Number of hours**
Proj1		
…		
	Total hours	

Seminar		**Number of hours**
Sem1		
…		
	Total hours	

TEACHING TOOLS USED	
N1.	Lecture: multimedia presentations of all parts of the course programme, presentation of computer software supporting bridge management.
N2.	Laboratory: multimedia presentations, software presentations, data preparation, data input and

processing by means of computer systems, analysis and discussion of the results. N3. Individual consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation (F – forming (during semester), P –concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01, PEU_W02	Colloquium
P (laboratory)	PEU_U01, PEU_U02, PEU_K01	Final laboratory report, active work in laboratory

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] 1. Russell S., Norvig P., Artificial Intelligence: A Modern Approach, Prentice Hall, 2009.
[2] Samarasinghe S., Neural Networks for Applied Sciences and Engineering: From Fundamentals Complex Pattern Recognition, Auerbach Publications – Taylor & Francis Group, 2006.
[3] Wang P. P., Ruan D., Kerre E. E., Fuzzy Logic: A Spectrum of Theoretical and Practical Issues, Springer, 2007.

SECONDARY LITERATURE:

[1] 1. Gurney K., An Introduction to Neural Networks, Taylor & Francis e-Library, 2005.
[2] Liebowitz J., The Handbook of Applied Expert Systems, CRC Press, 1999.
[3] Nguyen H. T., Prasad N. R., Walker C. L., Walker E. A., A First Course in Fuzzy and Neural Control, CHAPMAN & HALL/CRC, 2003.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Matematyczna homogenizacja i mikromechanika**
Name of subject in English:	**Mathematical Homogenization and Micromechanics**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory**~~/ optional / university-wide~~*****
Subject code:	**ASB000453**
Group of courses:	~~**YES**~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**		**30**		
Number of hours of total student workload (CNPS)	**90**		**60**		
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	~~Examination~~**/ crediting with grade ***	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**		**2**		
including number of ECTS points for practical (P) classes			**1**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**		**0.6**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of the mechanics of a continuous medium.
2. Knowledge of the strength of materials.

SUBJECT OBJECTIVES

C1. Acquire basic knowledge and skills in the field of multi-scale modeling.
C2. Developing skills in the field of composite media analysis.
C3. Expanding the knowledge of the mechanics of the continuous medium and the strength of materials.

C4. To consolidate the ability to work on the entrusted task and awareness of the need to search for new theoretical and practical solutions.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Students know the basic assumptions of mathematical homogenization and micromechanics PEU_W02 Students know and understand the principles of analytical and computational approaches in the framework of micromechanics. relating to skills: PEU_U01 Students correctly formulate problems of mathematical homogenization and micromechanics and use analytical or computational approaches to solve them. PEU_U02 Students can use selected computer codes for solving various boundary value problems; they can correctly prepare data for calculations; they can interpret and critically evaluate results of analysis. relating to social competences: PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. . PEU_K02 Students are aware of the necessity of verifying the computational approach used and the correctness of the results obtained

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Introduction	2
Lec2	Principles of mathematical homogenization theory; H-convergence, two-scale convergence, Γ-convergence	2
Lec3	Method of asymptotic developments: linear elasticity problem, heat flow problem	2
Lec4	Evaluation of effective properties of composite with periodic microstructure. Numerical implementation of periodic boundary conditions	2
Lec5	Principles of micromechanics. Direct and inverse problems. Simmulated annealing approach.	2
Lec6	Computational and analytical methods	2
Lec7	Analytical methods: Eshelby solution of single inclusion problem, bounds on effective properties	2
Lec8	Analytical methods: Maxwell approximation scheme, Mori-Tanaka approximation scheme	2
Lec9	Analytical methods: Self-Consistent approximation scheme, Differential Effective Medium approach	2
Lec10	Analytical methods: concentration parameter, average shape, equivalent microstructure approach	2
Lec 11	Computational micromechanics: statistical microstructure descriptors, notion of Representative Volume Element (RVE), minimum size of RVE	2
Lec 12	Computational micromechanics: Principles of Monte Carlo simulations, sufficient number of realizations (Central Limit Theorem, Chebyshev's Inequality)	2
Lec13	Computational micromechanics: numerical methods – Finite Volume	2

	Method, Finite Element Method	
Lec14	Estimation of effective properties based on digital image of microstructure: linear elasticity and heat flow problems	2
Lec15	Examples of applications of micromechanics to engeeniring problems	2
	Total hours	**30**

Laboratory		**Number of hours**
Lab1	Introduction. Discussion of the laboratory content and presentation of the rules for passing the course	2
Lab2	Computational micromechanics. Solving simple computational examples for determining the effective parameters of periodic microstructures – transport problems	2
Lab3	Computational micromechanics. Solving simple computational examples for determining the effective parameters of periodic microstructures – linear elasticity problems	2
Lab4	Computational micormechanics. Solving simple computational examples for determining the effective parameters of random microstructures – transport problems	2
Lab5	Computational micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – linear elasticity problems	2
Lab6	Analytical micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – transport problems.	2
Lab7	Analytical micromechanics. Solving simple computational examples for determining the effective parameters of random microstructures – linear elasticity problems.	2
Lab9	Determination of statistical microstructure descriptors.	2
Lab10	Determination of statistical microstructure descriptors.	2
Lab11	Solving simple inverse problems of micormechanics: determination of concentration parameter.	2
Lab12	Solving inverse problems of micormechanics: reconstruction of microstructure geometry.	2
Lab13	Solving inverse problems of micormechanics: reconstruction of microstructure geometry.	2
Lab14		2
Lab15	Completion of the course. Presentation of students' reports.	2
	Total hours	**30**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement

F1 (lecture) F2 (laboratory)	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K01 PEU_K02	Written exam Final report note
P=0.6*F1+0.4*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Milton G. W.: The Theory of Composites, Cambridge Univ. Press, 2002.
[2] Torquato S.: Random heterogeneous materials, Springer, 2000.
[3] Hornung U.: Homogenization and porous media, Springer, 1997.
[4] Łydżba D.: Effective properties of composites, Wrocław, 2011.
SECONDARY LITERATURE:
[1] Cherkaev A.: Variational methods for structural optimization, Springer, 2000.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Laboratoryjna identyfikacja właściwości mikrostrukturalnych kompozytów**
Name of subject in English:	**Laboratory identification of composite microstructure properties**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASB020553**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**15**		**30**		**15**
Number of hours of total student workload (CNPS)	**30**		**90**		**30**
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	~~Examination~~**/ crediting with grade ***	Examination / crediting with grade *	~~Examination~~ **/ crediting with grade** *
For group of courses mark (X) final course					
Number of ECTS points	**1**		**3**		**1**
including number of ECTS points for practical (P) classes			**2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**		**1**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of the mechanics of a continuous medium.
2. Knowledge of the strength of materials.

SUBJECT OBJECTIVES

C1. Acquire basic knowledge and skills in the field of laboratory tests of microstructures.
C2. Developing skills in the field of composite media analysis.
C3. Expanding the knowledge of the mechanics of the continuous medium and the strength of materials.
C4. To consolidate the ability to work on the entrusted task and awareness of the need to search for

new theoretical and practical solutions.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Students know advanced microstructural laboratory techniques. PEU_W02 Students know and understand the assumptions and principles of laboratory identification of geometrical and mechanical morphology of microstructure. relating to skills: PEU_U01 Students are able to correctly prepare a sample and conduct a test using advanced techniques for determining the geometrical and mechanical morphology of micro-heterogeneous materials. PEU_U02 Students are able to interpret the results as well as perform further extended analyzes using the data obtained from the study relating to social competences: PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. PEU_K02 Students are aware of the need to verify the applied methodology and the correctness of the obtained research results.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Introduction	1
Lec2	Physical and mathematical foundations of X-Ray computed tomography: Radon transform, Reconstruction procedure (Feldkamp algorithm).	2
Lec3	Statistical descriptors of digital representation of microstructure: volume porosity, fraction of open and closed pores, pore size distribution, pore shape distribution, tortuosity.	2
Lec4	Principles of nanoindentaion tests: Sneddon's solution, loading paths, evaluation of indentation depth, area of imprint.	2
Lec5	Grid Indentation Technique: histograms, segmentation, complex load paths, scales of observation, scale effect.	2
Lec6	Practical applications of nanoindentation technique.	2
Lec7	Principles of Scanning Electron Microscopy (SEM), evaluation of surface morphology descriptors.	2
Lec8	Practical applications of combined use of nanoindentation, X-Ray mCT and SEM. Completion of the course by students.	2
	Total hours	**15**

Laboratory		**Number of hours**
Lab1	Introduction.	2
Lab2	Presentation and discussion of equipment for laboratory tests: X-Ray mCT	2
Lab3	Presentation and discussion of equipment for laboratory tests: Nanoindentation	2

Lab4	Presentation and discussion of equipment for laboratory tests: SEM	2
Lab5	Preparation of samples for testing	2
Lab6	Imaging of microstructure of microheterogeneous materials with X-Ray mCT	2
Lab7	Reconstruction of microstructure from acuired plane images	2
Lab8	Determination of mechanical morphology of microheterogeneous materials: nanoindentation tests	2
Lab9	Determination of mechanical morphology of microheterogeneous materials: nanoindentation tests	2
Lab10	Numerical analysis of nanoindentation results. Deconvolution	2
Lab11	Determination of surface morphology by SEM	2
Lab12	Determination of surface morphology by SEM	2
Lab13	Students' own work: preparation of reports	2
Lab14	Students' own work: preparation of reports	2
Lab15	Students' own work: preparation of reports	2
	Total hours	**30**

Seminar		**Number of hours**
Sem1	Introduction	1
Sem2	Students' presentations	2
Sem3	Students' presentations	2
Sem4	Students' presentations	2
Sem5	Students' presentations	2
Sem6	Students' presentations	2
Sem7	Students' presentations	2
Sem8	Students' presentations	2
	Total hours	**15**

TEACHING TOOLS USED
N1. multimedia presentation N2. personal computer, interactive whiteboard (calculations, drawings, descriptions) N3. laboratory equipment

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Test
F2 (seminar)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Presentation
F3 (laboratory)	PEU_U01 PEU_U02 PEU_K01	Final Report note

	PEU_K02	
P=0.3*F1+0.3*F2+0.4*F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Milton G. W.: The Theory of Composites, Cambridge Univ. Press, 2002.
[2] Torquato S.: Random heterogeneous materials, Springer, 2000.
[3] Stock, S. R. (2019). Microcomputed tomography: methodology and applications. CRC press.
[4] Fischer-Cripps, A. C. (2009). Handbook of nanoindentation. Fischer-Cripps Laboratories Pty Ltd, Forestville, Australia.
[5] Goldstein, J. I., Newbury, D. E., Michael, J. R., Ritchie, N. W., Scott, J. H. J., & Joy, D. C. (2017). Scanning electron microscopy and X-ray microanalysis. Springer.
SECONDARY LITERATURE:
[1] Scrivener, K., Snellings, R., & Lothenbach, B. (Eds.). (2018). A practical guide to microstructural analysis of cementitious materials. Crc Press.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
Prof. Dariusz Łydżba, Dariusz.Lydzba@pwr.edu.pl
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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Praca dyplomowa**
Name of subject in English:	**Master (MSc) thesis**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Profile:	**academic / ~~practical~~***
Level and form of studies:	**~~1st /~~ 2nd level~~, uniform magister~~ studies*, full-time ~~/ part-time studies~~***
Kind of subject:	**obligatory ~~/ optional / university-wide~~***
Subject code:	**ASB029954**
Group of courses:	**~~YES /~~ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					
Number of hours of total student workload (CNPS)				**900**	
Form of crediting	Examination / crediting with grade *	Examination / crediting with grade *	Examination-/ crediting with grade *	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points				**30**	
including number of ECTS points for practical (P) classes				**30**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				**7,0**	

* delete as appropriate

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has an advanced theoretical knowledge and skills in accordance with the requirements of the field of study *Advanced Solid Mechanics* of the second cycle of the program, including Mechanics of Structure (MS) / Mechanics of Materials (MM) specialty.
2. Can shape, model, analyze, and measure complex structural components.
3. Knows the applicable standards, guidelines and regulations for the design of buildings, including the extended in the range of structures.
4. Has the ability and computational efficiency in design, including computer-aided calculation and plotting.
5. Has the ability to independently acquire, use, and analysis of scientific and technical information.

SUBJECT OBJECTIVES

C1. Synthesis of knowledge of the whole the second cycle studies and practical experience, especially in the chosen diploma specialty.

C2. Getting knowledge of the planning and realization of a variety, complex technical, scientific and technical research.
C3. Strengthening the knowledge of the principles of programming, modeling and solving complex engineering design tasks.
C4. Learning students how to select and use advanced computational tools, including computer programs.
C5. Strengthening skills of development the results and drawing conclusions.
C6. Strengthening the ability to use and critical analysis of scientific and technical information.

SUBJECT LEARNING OUTCOMES	
Relating to knowledge:	
PEU_W01	Has a well-established and extended knowledge of the issues of the construction industry, mechanics, particularly in the area of diploma specialization.
PEU_W02	Has a theoretically grounded knowledge of programming, modeling and solving complex design engineering tasks.
PEU_W03	Knows the rules for the application of advanced techniques and computer programs supporting the design and research processes.
Relating to skills:	
PEU_U01	Has detailed, developed skills in solving problems in the construction industry, mechanics in particular of the studying specialty.
PEU_U02	Has the ability to collect and critically analyze, from a variety of sources, of information in the field of construction, mechanics especially of the studying specialty.
PEU_U03	Can select the methods and tools to solve complex engineering tasks and basic research problems.
PEU_U04	Has the ability to document the work or research projects done by himself and their presentation.
PEU_U05	Is able to establish directions of further education and follow the process of self learning.
Relating to social competences:	
PEU_K01	Is able to set priorities for implementation of specified by himself or the others tasks or research projects and is responsible for his decisions.
PEU_K02	Has an internal belief in the need for the continuous self-development, including related to his profession.

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours**
Lec1		
…		
	Total hours	

Form of classes - class		**Number of hours**
Cl1		
...		
	Total hours	

Form of classes - laboratory		**Number of hours**
Lab1		

…		
	Total hours	

Form of classes - project		**Number of hours**
Proj1		
…		
	Total hours	

Form of classes - seminar		**Number of hours**
Sem1		
…		
	Total hours	

TEACHING TOOLS USED	
N1.	Studies of literature and other sources of information.
N2.	Preparation and execution of calculations and / or experimental and / or case study analysis.
N3.	Analysis of the comparisons results, summary, formulation of conclusions, editorial preparation of the thesis.
N4.	Participation in consultations related to the thesis, summarizing discussions.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation (F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1, P2, P3, P4	PEU_W01, PEU_W02, PEU_W03, PEU_U01, PEU_U02, PEU_U03, PEU_U04, PEU_U05, PEU_K01, PEU_K02	Rating the thesis by the supervisor and reviewer. Thesis defense. Diploma exam.
P1 – evaluation of the thesis by the supervisor and reviewer P2 – defense of the thesis P3 – evaluation of diploma exam		

PRIMARY AND SECONDARY LITERATURE
Literature depending on specialty in which the diploma is realized. Literature related to the thesis topic chosen independently by student and under the direction of the supervisor.
SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
Thesis supervisor.
MEMBERS OF TEH EDUCATIONAL TEAM (NAME AND SURNAME, E-MAIL ADDRESS)
Thesis reviewer

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Ocena ryzyka w geotechnice – zastosowania teorii pól losowych**
Name of subject in English:	**Risk assessment in geotechnics - implementation of Random Field Theory**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASB030553**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**45**		**15**		
Number of hours of total student workload (CNPS)	**90**		**60**		
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade *	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**		**2**		
including number of ECTS points for practical (P) classes			**1.2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**		**0.6**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic course in geotechnical engineering or basic course in soil mechanics
2. Basic course in statistics and probability
3. Calculus – engineering level

SUBJECT OBJECTIVES
C1. To enable students to recognise sources of uncertainty in geotechnics C2. To enable students to use probabilistic methods in their future work C3. To enable students to use selected computer tools for risk analysis in geoengineering C4. To teach students the basis of reliability based design in geoengineering

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Learn about probability distributions used for describing geotechnical parameters PEU_W02 Learn basics of random filed generation PEU_W03 Knows the parameters characterized random fields (scale of fluctuation, correlation matrix, autocorrelation function) PEU_W04 Learn the basics of stochastic finite element method relating to skills: PEU_U01 Is able to applied the random fields for soil spatial variability characterization PEU_U02 Knows the kriging technique and is able to use some kriging's software PEU_U03 Is able to operate software dedicated to reliability assessments available in the spreadsheets form PEU_U04 Is able to applicate stochastic finite element method to engineering problems PEU_U05 Can use reliability approaches in a design process relating to social competences: PEU_K01 Learn to work in a team PEU_K02 Is aware of the need to expand knowledge of modern techniques in geotechnical engineering

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	General comments on uncertainty in geotechnical analyses. Sources and types of uncertainty in geomechanical properties.	1
Lec 2	Stochastic processes and random fields – basic theory.	6
Lec 3	Common random fields models.	3
Lec 4	Probabilistic modelling of geomechanical properties. Spatial averaging.	4
Lec 5	Linear regression. Best linear unbiased estimation. Geostatistics-Kriging.	4
Lec 6	Basic of simulation techniques.	4
Lec 7	Simulation of random fields.	2
Lec 8	Reliability assessments in geotechnics with examples.	3
Lec 9	Applications in bearing capacity problems.	2
Lec 10	The Random Finite Element Method (RFEM). An overview.	4

Lec 11	RFEM applications to 2-D seepage problems and earthdam modelling.	2
Lec 12	RFEM application to shallow foundation settlement.	2
Lec 13	RFEM applications to earth pressure problem and slope stability analysis.	2
Lecture 14	Reliability based design.	6
	Total hours	**45**

Classes		**Number of hours**
Cl1	**Not applicable**	
	Total hours	

Laboratory		**Number of hours**
Lab1	Reliability measures evaluation using FORM/SORM methods, by means of dedicated software	7
Lab 2	Risk analysis of bearing capacity of foundation by FREM – numerical evaluations	8
	Total hours	**15**

Project		**Number of hours**
Proj1	**Not applicable**	
	Total hours	

Seminar		**Number of hours**
Sem1	**Not applicable**	
	Total hours	

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_W01 PEU_W02 PEU_W03	Oral exam
F2		
F3	PEU_U03 PEU_U04	
P=0.7*F1+0.3*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] FENTON G.A., GRIFFITHS D.V. (2008), *Risk assessment in geotechnical engineering*. John Wiley & Sons, Hoboken, N.J. [2] BAECHER G.B., CHRISTIAN J.T. (2003), *Reliability and Statistics in Geotechnical Engineering*. J. Wiley & Sons, Chichester. [3] FISZ M. (1980), *Probability theory and mathematical statistics*. Krieger Publ. Co. **SECONDARY LITERATURE:** [1] Probabilistic methods in geotechnical engineering. Ed. by D. V. Griffiths, Gordon A. Fenton. Wien; New York: **Springer**, cop. 2007. s. 127-145. ISBN: 978-3-211-73365-3. [2] *Eurocode 7 and reliability-based design*. In: *Reliability Based Design in Geotechnical Engineering*, Taylor and Francis, London–New York.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
Prof. dr hab. inż. Wojciech Puła, W-2/K09, wojciech.pula@pwr.edu.pl

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Zaawansowana Geoinżynieria**
Name of subject in English:	**Advanced Geoenginnering**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASB030653**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**			**15**	**15**
Number of hours of total student workload (CNPS)	**30**			**60**	**60**
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	Examination~~-~~/ crediting with grade *	~~Examination~~ **/ crediting with grade***	~~Examination~~ **/ crediting with grade ***
For group of courses mark (X) final course					
Number of ECTS points	**1**			**2**	**2**
including number of ECTS points for practical (P) classes				**1**	**1.2**
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**			**0.6**	**0.6**

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. 1. Fundamentals of bearing constructions in civil engineering, fundamentals of strength of materials and soil mechanics.
2. Basic types of foundations for different simple geoengineering conditions, geotechnical categories GC1 and GC2, construction processes of foundations, functional and environmental aspects of foundations depending on the type of object, loadings, soil conditions and water in soils.
3. Principles of soil-structure interacion for undeformable foundations, piles, embedded walls, retaining structures; calculation of the bearing capacity, stability of slopes, calculation of soil and water pressure.
4. Design of basic concrete elements, like beams, footings and columns; reinforcement calculation.
5. Solving of the simplest linear ordinary differential equations with constant coefficients.

SUBJECT OBJECTIVES
C1. Knowledge of wide range of methods for strengthening the soil for creating better contact conditions. C2. Developing knowledge through a spectrum of foundation methods, from direct foundation through soil reinforcement methods to indirect geotechnical structures. C3. Ability in modelling of the soil-structure interaction C4. Building an engineering intuition in prediction of internal forces in foundations and rational analysis of structures interacting with the subsoil. C5. Gaining knowledge in more complex problems of producing energy from geotechnical renewable sources. C6. Developing skills in design of foundation under spatial facilities as wind turbines, energy piles or energy tunnels. C7. Understanding the backgrounds of design approaches with partial safety factors due to the Eurocode 7.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Student gains a theoretical knowledge in calculation of foundation beams, as well as piles and walls embedded in soils, a better understanding of the method of strengthening the soil, PEU_W02 understands a theoretical background of the method of partial safety factors in geoengineering, uses the design approaches required by the Eurocode EC7-1 – the GEO stability criteria in this group, PEU_W03 understands problems of soil-structure interaction on the example of poor-loading subsoils, knows how to design pile constructions transmitting large loadings on the soil and produce energy relating to skills: PEU_U01 Student can define and apply appropriate calculation models for foundations and soils, analyses internal forces in foundations and combinations of such actions (also for mining excitations), PEU_U02 can select the appropriate technology based on material characteristics and soil and water conditions, PEU_U03 can interpret and use in design knowledge resulting from the results of geotechnical studies PEU_U04 becomes skillful in modelling of the soil-structure interaction problems, can calculate more complex foundations within the geotechnical category 2 and 3, relating to social competences: PEU_K01 student improves the ability to work alone and in a group of designers (due to discussions with other students during class-projects and with the teacher), PEU_K02 drills in logical thinking, clear formulation of theses and requirements, concentration on given tasks – within a given theory and set margins of assumptions.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Introduction. Preliminary information. Basic definitions.	2
Lec 2	Soil investigation methods	2
Lec3-4	Types of contact surfaces between the structure and the soil. The types of direct foundation methods	4

Lec5-7	Geotechnical conditions for the application of soil strengthening techniques. The spectrum of soil strengthening methods and the indirect foundation methods.	6
Lec8-9	Protection of deep excavations walls: types and applied technologies.	4
Lec10	The foundation of special facilities such as, i.e., wind turbines, energy piles, or briges.	2
Lec11-13	Application of geotechnical technologies to the process of producing energy from renewable sources.	6
Lec14	Impact of vibration caused by geotechnical works on various types of objects.	2
Lec15	Final test	2
	Total hours	**30**

Project		**Number of hours**
Pr1	Introduction	1
Pr2-4	Soil strengthening project	6
Pr5-7	Energy geostructure project	6
Pr8	Evaluation of reports – final report note evaluation	2
	Total hours	**15**

Seminar		**Number of hours**
Sem1	Introduction	1
Sem2-8	Students' presentations	14
	Total hours	**15**

TEACHING TOOLS USED
N1. multimedia presentation N2. personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02 PEU_W03	Fimal Test
F2 (project)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_K01 PEU_K02	Final Report note

F3 (seminar)	PEU_U01 PEU_U02 PEU_U03 PEU_U04 PEU_K01 PEU_K02	Oral presentation and raport
P=0.4*F1+0.3*F2+0.3*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Salgado, R. (2008). *The engineering of foundations* (Vol. 888). New York: McGraw Hill.

[2] Budhu, M. (2008). *Foundations and earth retaining structures*. John Wiley & Sons Incorporated..

[3] Eslami, A., Moshfeghi, S., Molaabasi, H., & Eslami, M. M. (2019). *Piezocone and Cone Penetration Test (CPTu and CPT) Applications in Foundation Engineering*. Butterworth-Heinemann.

[4] Laloui, L., & Di Donna, A. (2013). Energy geostructures. *ISTE and John Wiley & Sons*.

[5] Laloui, L., & Loria, A. F. R. (2019). *Analysis and design of energy geostructures: theoretical essentials and practical application*. Academic Press.

SECONDARY LITERATURE:

[1] Keller promotional materials

[2] A. Jarominiak, Lekkie konstrukcje oporowe, WKŁ, W-wa, 1999

[3] EN 1997-1:2004

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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Faculty of Civil Engineering, Wroclaw University of Science and Technology

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Zaawansowane konstrukcje zespolone stalowo-betonowe**
Name of subject in English:	**Advanced steel-concrete composite constructions**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory**~~/ optional / university-wide~~*****
Subject code:	**ASB030753**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**				**30**
Number of hours of total student workload (CNPS)	**90**				**60**
Form of crediting	**Examination** ~~/ crediting with grade*~~	Examination / crediting with grade*	Examination~~-~~/ crediting with grade *	Examination / crediting with grade *	~~Examination~~ **/ crediting with grade** *
For group of courses mark (X) final course					
Number of ECTS points	**3**				**2**
including number of ECTS points for practical (P) classes					**1.2**
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**				**0.6**

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Advanced knowledge of the mechanics of construction and civil engineering
2. Knowledge of the steel and concrete structures.
3. Basic knowledge of the steel-concrete composite constructions.
4. Knowledge of the FEM

SUBJECT OBJECTIVES
C1. Familiarization with contemporary steel-concrete composite structures. C2. Familiarization with advanced methods of laboratory tests of steel-concrete composite structures. C3. Familiarization with advanced methods of numerical simulation of behavior of steel-concrete composite structures. C4. Familiarization with shear connection using composite dowels.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 The student knows and understands solutions used in modern steel-concrete composite structures. PEU_W02 The student knows methodology of design and laboratory testing. relating to skills: PEU_U01 Has the skill to build a global computational model of composite structure. PEU_U02 Has the skill to build a local model of composite node and connection. relating to social competences: PEU_K01 The student is prepared to a team-work.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Subject and scope of the lecture, literature, rules of getting credit. State-of-the art of classic steel-concrete composite structures. Introduction to general composite section.	2
Lec2	Introduction to The History of the Theory of Structures. Working with old structures: strengthening and external prestressing of composite structures.	2
Lec3	Composite structures in buildings and bridges: main differences. Bridge construction – a strong driving force for developments in composite construction.	2
Lec4	Evolution of composite bridges. Basis of design of composite bridges. Un-cracked analysis and cracked analysis.	2
Lec5	From welded studs to composite dowels: evolution of shear connection. Fundamentals of Eurocode 4: steel skeleton.	2
Lec6	Evolution of composite dowels: from VFT to VFT-WIB.	2
Lec7	Composite dowels: searching for the shape and construction of first bridges. The first generation of bridges using composite dowels.	2
Lec8	Composite dowels: searching for design procedures and technology of production of steel part.	2
Lec9	Composite dowels: the final solution. Formal design procedures. The second generation of bridges using composite dowels.	2
Lec10	The concept of general composite section. The third generation of bridges using composite dowels. The forms constructed nowadays and predictable future.	2
Lec11	Laboratory testing of composite constructions: tests under static loads.	2
Lec12	Laboratory testing of composite constructions: tests under cyclic loads.	2

Lec13	FEM for purposes of laboratory testing:.	2
Lec14	FEM for purposes of design. Development of EC4.	2
Lec15	Colloquium	2
	Total hours	**30**

Seminar		**Number of hours**
Sem1	General introduction: organization, crediting rules. Distribution of individual tasks, discussion of each task.	1
Sem2	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem3	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem4	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem5	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem6	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem7	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem8	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem9	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem10	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem11	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem12	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem13	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem14	Presentation of a selected composite structure by a group of students, discussion of construction details and discussion of possible models, assumptions and methods for its design.	2
Sem15	Evaluation of the seminar.	2
	Total hours	**30**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01, PEU_W02	Colloquium
F (seminar)	PEU_U01, PEU_U02, PEU_K01	Active work during seminar.

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1Kurrer K-E. The History of the Theory of Structures: Searching for Equilibrium. Ernst & Sohn 2018.

[2] Lorenc, W. Composite dowels: the way to the new forms of steel-concrete composite structures. IABSE Symposium 20-22.05.2020, Poland.

[3] Jacques Berthellemy, Günter Seidl, Wojciech Lorenc Recent structures and bridges built with the CL steel-concrete connection. W: Tomorrow's Megastructures : 40th IABSE Symposium 2018, Nantes, France, 19-21 September 2018. Zurich : IABSE, 2018. art. S2-51, s. 1-9.

[4] Dennis Rademacher, Wojciech Ochojski, Wojciech Lorenc, Maciej P. Kożuch Advanced solutions with hot-rolled sections for economical and durable bridges. Steel Construction. 2018, vol. 11, nr 3, s. 196-204.

[5] Wojciech Lorenc Nośność ciągłych łączników otwartych w zespolonych konstrukcjach stalowo-betonowych. Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej, 2010. 131, [2] s.

[6] Wojciech Lorenc The model for a general composite section resulting from the introduction of composite dowels. Steel Construction. 2017, vol. 10, nr 2, s. 154-167.

[7] Wojciech Lorenc Non-linear behaviour of steel dowels in shear connections with composite dowels: design models and approach using finite elements. Steel Construction. 2016, vol. 9, nr 2, s. 98-106.

[8] Wojciech Lorenc The design concept for the steel part of a composite dowel shear connection. Steel Construction. 2016, vol. 9, nr 2, s. 89-97.

SECONDARY LITERATURE:

[9] Wojciech Lorenc. Nowe technologie budowy mostów zespolonych. W: Mosty hybrydowe : Seminarium Naukowo-Techniczne Wrocławskie Dni Mostowe, Wrocław, 29-30 listopada 2018 / [red. Jan Biliszczuk, Jerzy Onysyk]. Wrocław : Dolnośląskie Wydawnictwo Edukacyjne, [2018]. s. 101-118.

[10] Günter Seidl, Wojciech Lorenc Innovative Konstruktionen im Verbundbrückenbau mit Verbunddübelleisten. Stahlbau. 2018, Jg. 87, H. 6, s. 547-554.

[11] Wojciech Lorenc, Tomasz Kołakowski, Andrzej Hukowicz, Günter Seidl Verbundbrücke bei Elbląg : Weiterentwicklung der VFT-WIB-Bauweise. Stahlbau. 2017, Jg. 86, H. 2, s. 167-174.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Zaawansowana Mechnika Gruntów i Modelowanie Współpracy Konstrukcji z Gruntem**
Name of subject in English:	**Advanced Soil Mechanics and Soil – Structure Interaction**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASB030853**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**		**30**		
Number of hours of total student workload (CNPS)	**90**		**60**		
Form of crediting	**Examination** ~~/ crediting with grade*~~	Examination / crediting with grade*	~~Examination./~~ **crediting with grade ***	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**		**2**		
including number of ECTS points for practical (P) classes			**1.2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**		**0.6**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge in Mechanics, Strength of Materials, and general principles of design of Civil Engineering Structures
2. Basic knowlege of geology

SUBJECT OBJECTIVES

C1. To learn the methods of computing stress and deformation of soil substrate taking the specifics of soil medium into account.
C2. To get the knowledge of theoretical description of water flow in soil medium.
C3. To learn the basics of hydro-mechanical coupling and its implications to practical problems.

C4. To learn the basics of soil plasticity, theory of limit states, methods for determining the bearing capacity of foundations and analyzing the stability of slopes.
C5. To acquire the ability to correctly formulate computational models of typical problems in geotechnics, solve them and interpret the results obtained.
C6. To learn the basics of modelling the interaction between the engineering structures and soil substrate.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 Students know the basic assumptions and constitutive laws used in soil mechanics.
PEU_W02 Students know and understand the principles of computer-aided modelling and calculation of geotechnical structures

relating to skills:
PEU_U01 Students correctly formulate problems concerning the interaction of the structure with the subsoil and use computer codes to solve them.
PEU_U02 Students can use selected computer codes supporting modelling of geoengineering structures; they can correctly prepare data for calculations; they can interpret and critically evaluate results of numerical analysis.

relating to social competences:
PEU_K01 Students are able to work in a group on a given task, carrying out an informative discussion to develop an effective and efficient method of finding a correct solution. .
PEU_K02 Students are aware of the necessity of verifying the computational approach used and the correctness of the results obtained.

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec1	Formation and classification of soils	2
Lec2	Basic relations in the theory of elasticity. Uniaxial strain and plane strain states. Analytical solutions for uniform soil half-space.	2
Lec3	Settlements in uniaxial strain state. Virgin compression and unloading/reloading lines. Compression and recompression indices.	2
Lec4	In situ stresses in soils. Concept of effective stress.	2
Lec5	Darcy Law. General equation of water flow in soil. Soil-water characteristic curve.	2
Lec6	One dimentional consolidation. Hydromechanical coupling.	2
Lec7	Mohr-Coulomb strength criterion. Mohr circles. Active and passive earth pressures.	2
Lec8	Limit states theorems. Lower and upper bound of critical load for strip foundation. Finite element limit analysis.	2
Lec9	Platicity theory in the view of numerical methods.	2
Lec10	Slope stability. Angle of natural slope. Kinemtic method. Examples.	2
Lec 11	Fellenius and Bishop methods. Shear strength reduction technique. Examples.	2
Lec 12	Models of soil-structure contact zone in the view of numerical methods. Stifness of contact.	2
Lec13	Examples of numercial computations in practical geotechnical problems.	2
Lec14	Examples of numercial computations in practical geotechnical problems -	2

	continuation.	
Lec15	Examples of numercial computations in practical geotechnical problems - continuation. Lecture summary.	2
	Total hours	**30**

Laboratory		**Number of hours**
Lab1	Modelling of soil subsrate. Variability of layers' thickness. Spatial variability of parameters.	2
Lab2	Elasticity. Formulartion of boundary-value problem.	2
Lab3	Solving geotechnical problems using elastic model.	2
Lab4	Solving geotechnical problems using the concept of effective stress.	2
Lab5	Solving of individualy assigned problems by students and preparation of a report No. I	2
Lab6	Water flow in soil. Formulation of initial boundary-value problem.	2
Lab7	Modelling of problems with changing phreatic surface.	2
Lab8	Problem of consolidation.	2
Lab9	Solving of individualy assigned problems by students and preparation of a report No. II	2
Lab10	Assesment of slope stability using limit equlibrum methods.	2
Lab11	Assesment of slope stability using sher strength reduction technique. Discussion of diffrences in results between the methods.	2
Lab12	Solving of individualy assigned problems by students and preparation of a report No. III	2
Lab13	Modelling of soil embedded structures considering soil-structure interaction.	2
Lab14	Modelling of soil embedded structures considering soil-structure interaction, continuation.	2
Lab15	Solving of individualy assigned problems by students and preparation of a report No. IV	2
	Total hours	**30**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K02	Written exam
F1 (laboratory)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Reports

P=0.6*F1+0.4*F2

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Verruijt, A. (2001). Soil mechanics. Delft: Delft University of Technology.
[2] Das, B.M. (2019). Advanced soil mechanics. CRC Press. 5th Ed.
[3] Derski,W, Izbicki, R., Kisiel, I., Mróz, Z. (1988). Rock and soil mechanics. PWN/Elsevier
[4] Commend, S., Kivell, S., Obrzud, R.F., Podleś, K., Truty, A., & Zimmermann, T. (2018). Computational geomechanics. Getting started with ZSOIL. PC. Rossolis Editions. V Ed.

SECONDARY LITERATURE:

[1] EN 1997-1 Eurocode 7: Geotechnical Design - General Rules
[2] Fredlund, D.G, Rahardjo, H., Fredlund, M.D. (2012). Unsaturated Soil Mechanics in Engineering Practice. Wiley
[3] de Vallejo, L.G., Ferrer, M. (2011). Geological engineering. CRC Press/Balkema.
[4] FlexPDE User Manual
[5] Itasca Flac User Manual
[6] ZSoil User Manual

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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DR INŻ. MACIEJ SOBÓTKA
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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Zaawansowane nanomateriały**
Name of subject in English:	**Advanced Nano-materials**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASM003001**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**		**30**	**30**	
Number of hours of total student workload (CNPS)	**90**		**30**	**30**	
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	~~Examination~~**/ crediting with grade** *	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**		**1**	**1**	
including number of ECTS points for practical (P) classes			**1**	**1**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			**0.6**	**0.6**	

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of Mechanics and Materials Science.
2. Knowledge of chemistry and physics at least at the advanced level of high school
3. Knowledge of basic experimental mechanics

SUBJECT OBJECTIVES

C1. To learn the production of amorphous and nanocrystalline alloys by different rapid quenching methods
C2. Knowledge of experimental methods for determining the crystallization kinetics of amorphous metallic materials
C3. Learn to analize mechanical and magnetic properties of amorphous and nanocrystalline metallic alloys

C4. Learn to analyze the influence of chosen structural parameters on nanomaterials application
C5. Be able to indicate the form of the material for a specific application
C6. Acquiring skills of scientific cooperation in a team obtaining and analyzing different form of sol-gel materials.
C7. Acquisition of basic knowledge in the development of scientific expertises

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 Has extensive knowledge of operation of measurements systems.

relating to skills:
PEU_U01 Is able to use different methods of materials properties measurements (e.g. wettability, spectroscopy, electrochemistry, mechanical)
PEU_U02 Is able to analyse results of chosen measurements of nanomaterials properties (e.g. wettability, spectroscopy, electrochemistry, mechanical)

relating to social competences:
PEU_K01 Can think and act in a creative and entrepreneurial way. Can appropriately determine priorities in order to accomplish tasks and problems defined by themselves or others
PEU_K02 Is able to work in a group, taking various roles in it.

PROGRAMME CONTENT

Lecture		**Number of hours**
Lec1	Production of amorphoys and nanocrystalline metallic alloys by rapid quenching methods	2
Lec2	Microsructure studies and crystallization kinetics of amorphous alloys	2
Lec3	Soft and hard magnetic properties of ferromagnetoic amorphous and nanocrystalline alloys. Magnetocaloric and shape memory alloys.	2
Lec4	Mechanical properties analysis of multifunctional alloys	2
Lec5	Advanced, functional nanomaterials obtained by sol-gel method – general overview	2
Lec6	Differences in the production of various forms of sol-gel nanomaterials and methods of application.	2
Lec7	The variety of functionalisation methods for base sol-gel matrices	2
Lec8	POWDERS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec9	THIN FILMS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec10	AEROGELS - unique properties and measurement methods of advanced sol-gel nanomaterials	2
Lec11	Advanced measurement techniques in determining the mechanical properties of sol-gel nanomaterials	2
Lec12	Advanced mechanical properties of complex sol-gel materials	2
Lec13	Effects of magnetostriction, electrostriction and photostriction in advanced matarials	2
Lec14	When MEMS goes into NEMS	
Lec15	Case study - analysis of structural, surface and mechanical properties of chosen type of sol-gel materials and searching for potential applications	2

	Total hours	**30**

Laboratory		**Number of hours**
Lab1	Production of amorphous metallic ribbons and bulk metallic alloys	3
Lab2	Investigations of magneticaloric effect and other magnetic properties in wide range of temperature and magnetic field	3
Lab3	Mechanical parameters studies of multifunctional metallic materials with different grain size	3
Lab4	Different ways of powders, thin films and aerogels synthesis	3
Lab5	Methods of thin films application	3
Lab6	Structural and porosity analysis of different forms of sol-gel oxides	3
Lab7	Protection properties of sol-gel materials	3
Lab8	Optical properties of sol-gel materials	3
Lab9	Different way in determining the mechanical properties of sol-gel nanomaterials	3
Lab10	Cross-effect in advanced materials	3
	Total hours	**30**

Project		**Number of hours**
Pro1	Selection of production parameter of amorphous metallic ribbons and bulk metallic alloys	3
Pro2	Analysis of investigations of magnetocaloric effect and other magnetic properties in wide range of temperature and magnetic field and their influence on potential application	3
Pro3	Analysis of mechanical parameters of multifunctional metallic materials with different grain size and their influence on potential applications	3
Pro4	Influence of selected manufacturing parameters on the properties of the obtained materials and their final application	3
Pro5	Analysis of the influence of structure and porosity on the insulating properties of sol-gel materials	3
Pro6	Selection of protective parameters of sol-gel materials for the selected application	3
Pro7	Advanced methods in determining the mechanical properties of sol-gel nanomaterials	3
Pro8		3
Pro9	Design and development of device based on advanced materials	3
Pro10	Cross-effects for measurement techniques in nanotechnology	3
	Total hours	**30**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement

P1 (lecture) F2 (classes) F3 (laboratory) 	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K01 PEU_K02 PEU_U01 PEU_U02 PEU_K01 PEU_K02	Written exam Test Final Report note
P=0.6*F1+0.2*F2+0.2*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] K.H.J. Buschow, Handbook of Magnetic Materials, vol. 12, Elsevier Science
[2] M. Miller, P. Liaw, Bulk Metallic Glasses – An Overview, Springer
[3] Muhammed Musaddique Ali Rafique, Bulk metallic glasses and thei composites, Momentum Press
[4] C. J. Brinker and G. W. Scherer, Sol-gel Science: The Physics and Chemistry of Sol-gel Processing. San Diego: Gulf Professional Publishing, 1990
[5] D. Levy and M. Zayat, Eds., The Sol-Gel Handbook - Synthesis, Characterization, and Applications: Synthesis, Characterization and Applications. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2015

SECONDARY LITERATURE:

[1] P. W. Atkins, J. de Paula, and J. Keeler, Atkins' Physical Chemistry, 11th ed. Oxford: Oxford University Press, 2018
[2] Gross, D., & Seelig, T. (2017). *Fracture mechanics: with an introduction to micromechanics*. Springer.
[3] current literature in international journals, e.g. from *sciencedirect.com* database

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Mechanika Analityczna**
Name of subject in English:	**Analytical Mechanics**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASM003002**
Group of courses:	~~YES /~~ **NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**	**15**	**15**		
Number of hours of total student workload (CNPS)	**30**	**30**	**30**		
Form of crediting	Examination	**crediting with grade***	**crediting with grade***	Examination/ crediting with grade *	Examination= / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**2**	**1**	**2**		
including number of ECTS points for practical (P) classes		**1**	**2**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**	**0,7**	**0.6**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical analysis (differential and integral calculus)
2. Linear algebra (matrices, determinants), geometry, trigonometry
3. Mechanics I and mechanics II in range of study stage I

SUBJECT OBJECTIVES

C1. Knowledge of analytical methods for the application of Lagrangian mechanics in the dynamics of mechanical holonomic systems (for systems with constrains depending and not depending from time). Knowledge of vibration analysis of linear holonomic conservative systems with many degrees of freedom.

C2. Ability to independently analyze complex mechanical systems with a holonomic constrains

which are not depend on time to determine : differential equations of movement, natural vibration frequency spectrum, the modal matrix.

C3. The acquisition and consolidation of social skills including emotional intelligence relying ability to work in a group of students with a view to effective problem solving. Responsibility, honesty and fairness in conduct; observance of manners in the academic community and society

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Students can define a discrete mechanical holonomic system and its possible and virtual displacements; know the fundamental problem of dynamics; know the classification of dynamical systems in respect of the constrain types; know the general equation of dynamics and the principle of virtual work..

PEU_W02 Students know the notion of generalized coordinates and configuration space of a dynamical system; know the concept of generalized forces (active and inertia); know the Lagrange's equations of the second kind

PEU_W02 Students know the vibration theory of linear systems with many degrees of freedom in the free vibration range.

relating to skills:

PEU_U01 Students are able to apply the virtual work principle and d'Alembert's principle for holonomic systems

PEU_U02 Students can derive the differential equations of motion of discrete dynamical systems by using Lagrange's equations and by using the energy conservation law for conservative holonomic systems.

PEU_U03 Students can calculate the spectrum of natural frequencies and can determine the modal matrix for discrete conservative linear systems.

relating to social competences:

PEU_K01 Students can search information and is able to critical review

PEU_K02 Students can objectively evaluate the arguments and rationally explain and justify own point of view.

PEU_K03 Students can observe the customs and rules of the academic community.

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec1	Curriculum. Requirements. Examples of dynamic systems. Constrains and their types, classification systems for the sake of the constrain types (holonomic systems), possible velocities and possible displacements.	2
Lec2	The fundamental problem of dynamics, virtual displacement, the notion of ideal constraints, the general equation of dynamics, the virtual work principle.	2
Lec3	The dynamic general equation for the rotational and planar motion of rigid body (examples)	2
Lec4	Generalized coordinates. Derivation of differential equations of motion by usins the energy conservation law expressed in generalized coordinates (examples).	2
Lec5	Generalized forces. Configuration space. Lagrange's equations (of II type).	2
Lec6	Lagrange's equations (cont. examples, applications). Lagrangian.	2

Lec7	Linear systems with a finite number of degrees of freedom, matrix notation, conservative systems.	2
Lec8	Free vibrations of conservative systems: natural frequencies, modal matrices, mode shapes.	2
Lec9	Harmonically forced vibration, frequency characteristics, an example of oscillation analysis of two- degree- of- freedom system.	2
Lec10	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.	2
Lec11	The dynamic equations for general motion of rigid body (Euler's equation).	2
Lec12	Gyroscope (approximate theory).	2
Lec13	An outline of linear elastic particle collisions theory, inelastic collision rate.	2
Lec14	Variational approach of Lagrangian mechanics.	2
Lec15	The central Lagrange's equation. Fundamental integral mechanical principle (Hamilton's principle)	2
	Total hours	**30**

Classes		**Number of hours**
Cl 1	Introduction. Derivation of equations for possible velocities and virtual displacements.	2
Cl 2	Solving of static problems by using a principle of virtual work	2
Cl 3	Solving of dynamic problems for discrete systems by using a dynamic general equation (d'Alembert's principle).	2
Cl 4	Solving of selected dynamic problems of a rigid body in plane motion by using a dynamic general equation.	2
Cl 5	Derivation of motion differential equations based on the energy conservation law and Lagrange's equations (comparison of methods and results) for systems with one and two degrees of freedom	2
Cl 6	Determination of the natural frequencies and modal parameters for conservative systems with two degrees of freedom	2
Cl 7	Final test	2
Cl 8	Credits. Improvement of marks	1
	Total hours	**15**

Laboratory		**Number of hours**
Lab1	Introduction. Getting familiar with the software Matlab and Simulink.	2
Lab2	Computer analysis of some dynamic system in case of plane motion by using dynamics equations of analytical mechanics	2
Lab3	Design by means of Simulink a dynamical system with one degree of freedom and computer analysis of the free and forced vibration.	2
Lab4	Analysis of free and forced vibration of a linear two-mass with two degrees of freedom system using Simulink software.	2
Lab5	Simulation studies a dynamic system proposed by the student and approved by the laboratory conductor.	2
Lab6	Experimental studies of vibration of selected real systems with a finite	2

	number of degrees of freedom (1 or/and 2). Introduction to the measuring apparatus, vibration sensors, methods of excitation, vibration analyzers, etc	
Lab7	Experimental investigation of a continuous dynamic system (beam and/or plate). Resonant frequencies, mode shapes.	2
Lab8	Evaluating the effects of activities, reports. Credits.	1
	Total hours	**15**

TEACHING TOOLS USED
N1. traditional lecture with the use of transparencies and slides
N2. calculative-problematic exercises
N3. tutorials
N4. self study - preparation for laboratory class
N5. self studies and preparation for examination

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02, PEU_W03, PEU_K01, PEU_K02, PEU_K03, PEU_U01, PEU_U02, PEU_U03	Calculative-problematic exercises
F2 (classes)	PEU_U01, PEU_U02, PEU_U03	Final test, oral answers
F3 (laboratory)	PEU_K01, PEU_K02, PEU_K03, PEU_U01, PEU_U02, PEU_U03	laboratory reports, oral answer
P=0.6*F1+0.2*F2+0.2*F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Jerry Ginsberg, *Engineering Dynamics*, Cambridge
[2] Meriam, Kraige, *Dynamics*
[3] Gross D., Hauger W., Schroder J., Wall W.A., Govindjee S., *Engineering Mechanics 3,* Springer
[4] Housner G.W., Hudson D.E*., Applied Mechanics* – Dynamics
[5] *M. Lunn, A First Course in Mechanics, Oxford Science Publications, 1991.*

PRIMARY LITERATURE:

[1] J. Zawadzki, W. Siuta, "General Mechanics", PWN, Warsaw, 1971;
[2] B. Skalmierski, "Mechanics", PWN, Warsaw, 1982;
[3] M. Kulisiewicz St. Piesiak, "Methodology of modeling and identification of mechanical dynamical systems", WUT. , 1994;
[4] J. Leyko, "General Mechanics", WNT, Warsaw, 1980;
[5] J. Giergiel, "General Mechanics", WNT, Warsaw, 1980

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Projektowanie Materiałów Inżynierskich**
Name of subject in English:	***Design of Engineering Materials***
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~**1st /**~~ **2nd level**~~**, uniform magister**~~**studies*, full-time** ~~**/ part-time studies***~~
Kind of subject:	**obligatory** ~~**/ optional / university-wide***~~
Subject code:	**ASM003003**
Group of courses:	~~**YES**~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**			**30**	
Number of hours of total student workload (CNPS)	**60**			**60**	
Form of crediting	~~Examination /~~ **crediting with grade** *	Examination / crediting with grade *	Examination / crediting with grade *	~~Examination /~~ **crediting with grade ***	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**			**2**	
including number of ECTS points for practical (P) classes				**1**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**			**0.7**	

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge in such disciplines as: Materials science, Strength of materials, Manufacturing technology, processing and recycling of materials, design and examination methods of structure and properties of materials
2. Skills in usage of technical data and specialized computer software.
3. Skills in collaboration with other users of engineering materials and specialists in the fields of design, manufacturing, processing, and application of materials.

SUBJECT OBJECTIVES

C1. Obtaining the skills in design of chemical composition and structure of engineering materials to produce products with desired mechanical and operational properties.
C2. Obtaining the skills in materials selection for technical applications)
C3. Obtaining the skills in failure analysis of materials and design of repair processes for

improvement of products durability.
C4. Acquisition of basic knowledge in the development of scientific expertises

SUBJECT LEARNING OUTCOMES
Knowledge: PEU_W01 - Possesses advanced knowledge on structure- properties relationship as well as on strengthening mechanisms in materials and their practical usage for material design of products. PEU_W02 - Knows the criteria and methodology of materials selection and can participate in engineering design of products. **Skills:** PEU_U01 – Able to design the materials structure in order to obtain the desired operational properties of product. PEU_U02 – Able to conduct the failure analysis of material and design the repair process for improvement of product durability. **Social skills:** PEU_K01 – Possesses the collaboration skills and able to lead the research teams in engineering design process. PEU_K02 – Is prepared to conduct the research on materials design of products.

PROGRAMME CONTENT		
Form of classes - lecture		Number of hours
Lec1	Introduction to design of metallic materials. Effect of chemical composition, processing and microstructure on the properties of materials.	2
Lec2	The role and significance of alloy phase diagrams in design of materials.	2
Lec3	Strengthening mechanisms in metals and alloys - theory and practice	2
Lec4	Influence of manufacturing technology on selected properties of metallic alloys	2
Lec5	Tailored material properties for engineering applications using incremental techniques - techniques, properties - strength analysis	2
Lec6	The role of manufacturing defects on the residual strength of materials	2
Lec7	Design of non-metallic materials - an introduction to fibrous composites	2
Lec8	Manufacturing technologies of composite materials	2
Lec9	Forming machine parts of composite materials - design philosophy	2
Lec10	Thermpolastic matrix composites - examples of fabrication and strength orienting tailored structures	2
Lec 11	Duroplastic matrix composites - examples of manufacturing and strength orienting of tailored structures	2
Lec 12	An example of individualized material design for engineering applications - case study analysis	2
Lec13	Hyperelastic materials and modeling of mechanical behavior	2
Lec14	Metal matrix composites - fundamentals in design.	2
Lec15	Criteria and quantitative methods of materials selection in engineering design.	2
	Total hours	**30**

Form of classes - laboratory	**Number of**

		hours
Proj1	Selection of material for chosen structural component	2
Proj2	Design of chemical composition of steel with desired hardenability.	2
Proj3	Design of microstructure of steel in the process of heat treatment - part I.	2
Proj4	Design of microstructure of steel in the process of heat treatment - part II.	2
Proj5	Selection of material for selected structural component - project- part II.	2
Proj6	Design of metallic materials using additive technologies for specific complex structures	4
Proj7	Rapid Prototyping of products made of polymers and ceramics	4
Proj8	Design of composite materials and pultrusion system for manufacturing closed and open sections for industrial application	2
Proj9	Selection of composite materials for cylindrical structures and design of manufacturing methods	2
Proj10	Hybrid layered materials – design and selection of manufacturing processes	2
Proj11	Case study I – fatigue resistance materials design and selection	2
Proj12	Case study II – creep resistant material design and selection	2
Proj13	Preparation of reports and discussion of the selected issue - the design of the production of a material tailored to the operational requirements	2
	Total hours	**30**

TEACHING TOOLS USED
N1. multimedia presentation N2. personal computer, interactive whiteboard (calculations, drawings, descriptions), N3 project presentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Written exam
P=F1		
F2 (project)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Evaluation and defense of a developed project
P=F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Ashby, M. F., & Jones, D. R. (2012). Engineering materials 1: an introduction to properties, applications and design (Vol. 1). Elsevier.
[2] Barbero, E. J. (2017). *Introduction to composite materials design*. CRC press.
[3] Ashby, M. F., Shercliff, H., & Cebon, D. (2018). *Materials: engineering, science, processing and design*. Butterworth-Heinemann.
[4] BROCKS, Wolfgang. Plasticity and Fracture. Springer International Publishing, 2018.

[5] Bank, L. C. (2006). *Composites for construction: structural design with FRP materials*. John Wiley & Sons.

SECONDARY LITERATURE:

[1] Mueller, B. (2012). Additive manufacturing technologies–Rapid prototyping to direct digital manufacturing. *Assembly Automation*.
[2] Gu, D. (2015). *Laser additive manufacturing of high-performance materials*. Springer.
[3] Bart, J. C. (2005). „Additives in polymers. *Industrial analysis and application*.
[4] Chua, C. K., Wong, C. H., & Yeong, W. Y. (2017). *Standards, quality control, and measurement sciences in 3D printing and additive manufacturing*. Academic Press.
[5] Campbell Jr, F. C. (Ed.). (2003). *Manufacturing processes for advanced composites*. elsevier..

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MEMBERS OF THE EDUCATIONAL TEAM (NAME AND SURNAME, E-MAIL ADDRESS)

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Mechanika Pękania**
Name of subject in English:	**Fracture mechanics**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Structure (MS) / Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory** ~~/ optional / university-wide~~*****
Subject code:	**ASM003004**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**	**15**	**15**		
Number of hours of total student workload (CNPS)	**90**	**30**	**30**		
Form of crediting	**Examination** / ~~crediting with grade~~ *	~~Examination~~ **/ crediting with grade***	~~Examination~~**/ crediting with grade ***	Examination / crediting with grade *	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**	**1**	**1**		
including number of ECTS points for practical (P) classes		**1**	**1**		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)		**0.6**	**0.6**		

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of Mechanics& Strength of Materials principles.
2. Knowlege of differential equations and fundamental linear algebra.
3. Knowledge of basic experimental mechanics

SUBJECT OBJECTIVES

C1. To learn the stress field parameters in front of the crack tip
C2. Knowledge of experimental methods of fracture mechanics including determination of fracture toughness measures for engineering materials (metals, composites, polymers)
C3. To learn fatigue crack propagation model identification and fatigue crack growth analysis - fatigue lifetime calculation

C4. Learn to analyze the fracture and crack growth process under complex stress conditions
C5. Be able to know the fracture pattern and determine the cause of failure of a structural members
C6. Acquiring skills of scientific cooperation in a team analyzing fatigue damage.
C7. Acquisition of basic knowledge in the development of scientific expertises

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Knowledge of linear and nonlinear models of fracture mechanics. PEU_W02 Knowledge of methods for fatigue crack growth lifetime calculation under uniaxial and multiaxial loading conditions relating to skills: PEU_U01 Can estimate fundamental parameters of fracture mechanics like K, J, G for structural members PEU_U02 Can use mathematical and experimental methods for fatiguelifetime prediction relating to social competences: PEU_K01 Can objectively evaluate the arguments as well as rationally explain and justify the own point of view. PEU_K02 Can search information and is able to review it critically

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Theoretical Strength of Materials – defects in materials	2
Lec2	Griffith's theory and elastic stress field – Stress intensity factor definition	2
Lec3	Plastic zones ahead of a crack tip, nonlinear fracture mechanics (CTOD, J)	2
Lec4	Brittle and ductile fracture of metals, polymers and composites– fractography analysis	2
Lec5	Experimental methods in fracture mechanics and fatigue of materials – determination of the characteristics in a uniaxial loading condition	2
Lec6	Initiation of fatigue cracks in the material - microstructural aspects of the fatigue process. Low- and high-cycle Fatigue	2
Lec7	Fatigue crack growth (mode I); fatigue crack growth curve, micro-crack growth mechanisms.	2
Lec8	Factors influencing fatigue crack growth rates	2
Lec9	Fundamentals of the degradation theory and its influence on fatigue and fracture properties of materials and structures	2
Lec10	Multiaxial stress state; fracture toughness characterization	2
Lec 11	Mixed-mode fatigue cracks growth. Predicting of fatigue crack paths and fatigue lifetime estimation	2
Lec 12	Multiaxial fatigue - an overview of existing solutions for proportional and non-proportional loads	2
Lec13	Variable and random loading – calculation methods and fatigue damage rules	2
Lec14	Case study - analysis of fatigue crack growth in structural components and damage analysis - example of expertise elaboration - description of a fracture surface	2
Lec15	The probabilistic approach in fracture mechanics and defect tolerance	2

	modelling	
	Total hours	**30**

Classes		**Number of hours**
Cl1	Solving of the exercises with a solid body containing cracks using linear elastic fracture mechanics	2
Cl2	Solving of the exercises s with a solid body containing cracks using elastoplastic fracture mechanics	2
Cl3	Fatiguelifetime calculations with Paris law using standardized specimens and SIF solutions	2
Cl4	Fatiguelifetime calculations with Paris law using complex geometry structural members	2
Cl5	Fatiguelifetime calculations under variable amplitude loading conditions	2
Cl6	Fatiguelifetime calculations and crack paths analysis under mixed-mode loading conditions	2
Cl7	Case study calculation analysis – solution of the complex problem of structural members and structures in the scope of fatigue and fracture	2
Cl8	Test and own analysis of the selected problem	1
	Total hours	**15**

Laboratory		**Number of hours**
Lab1	Fracture toughness – K determination for metals and non-metals	2
Lab2	Fracture toughness – G determination for composite materials	2
Lab3	Nonlinear elasto-plastic parameters determination (J, CTOD) for metals	2
Lab4	Fracture characterization of polymers (Essential Work of Fracture)	2
Lab5	Mixed-mode fracture toughness characterization of materials	2
Lab6	Fatigue crack growth rate measurement and crack closure evaluation	2
Lab7	Mixed-mode fatigue crack growth	2
Lab8	Evaluation of reports – final report note evaluation	1
	Total hours	**15**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement

F1 (lecture) F2 (classes) F3 (laboratory) 	PEU_W01, PEU_W02 PEU_U01 PEU_U02 PEU_K01 PEU_K02 PEU_U01 PEU_U02 PEU_K01 PEU_K02	Written exam Test Final Report note
P=0.6*F1+0.2*F2+0.2*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Anderson T.L. Fracture Mechanics. Fundamentals and Applications, Fourth Edition. — CRC Press,

[2] Gdoutos, E. E. (2020). Fracture mechanics: an introduction (Vol. 263). Springer Nature.

[3] Farahmand, B., Bockrath, G., & Glassco, J. (2012). *Fatigue and fracture mechanics of high risk parts: application of LEFM & FMDM theory*. Springer Science & Business Media.

[4] BROCKS, Wolfgang. Plasticity and Fracture. Springer International Publishing, 2018.

[5] Avellar, L., & Mac Donald, K. (2019). Mechanics of Materials and Fracture for High School Students. In Fracture, Fatigue, Failure and Damage Evolution, Volume 6 (pp. 111-114). Springer, Cham.

SECONDARY LITERATURE:

[1] Lesiuk, G., Correia, J.A.F.O., Krechkovska, H.V., Pekalski, G., Jesus, A.M.P. de, Student, O., Degradation Theory of Long Term Operated Materials and Structures, Springer, 2021

[2] Saxena, A. (2019). Advanced Fracture Mechanics and Structural Integrity. CRC Press.

[3] BROEK, David. *The practical use of fracture mechanics*. Springer Science & Business Media, 2012.

[4] Moore, D. R., Williams, J. G., & Pavan, A. (2001). *Fracture mechanics testing methods for polymers, adhesives and composites*. Elsevier.

[5] Gross, D., & Seelig, T. (2017). *Fracture mechanics: with an introduction to micromechanics*. Springer.

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Inżynieria wynalazczości**
Name of subject in English:	**Inventive Engineering**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory**~~/ optional / university-wide~~*****
Subject code:	**ASM003005**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**			**15**	
Number of hours of total student workload (CNPS)	**60**			**90**	
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	Examination**-/** crediting with grade *	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**2**			**3**	
including number of ECTS points for practical (P) classes				**1**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				**0.6**	

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The ability to design technical objects.
2. Ability to model CAD geometric parts and assemblies.
3. Ability to work in a team.

SUBJECT OBJECTIVES

C1. Acquiring knowledge about the methods of designing inventions with high innovative potential using systematic and heuristic methods.
C2. Acquisition of knowledge in the field of innovation assessment using objective methods.
C3. Acquisition of knowledge in the area of building inventive teams and acquiring knowledge
C4. Acquiring the skills of conceptual design with the use of prototyping
C5. Acquiring the ability to plan and conduct inventive workshops using heuristic and systematic methods such as TRIZ, Synectics, Design Thinking
C6. Acquiring skills in the field of commercialization of inventions and financing engineering

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: PEU_W01 Student knows and understands the cycle of conceptual design according to the Inventive methodology Engineering. PEU_W02 A student has knowledge of conceptual design and prototyping products and services PEU_W03 A student has knowledge of the development of a design concept and engineering of financing the commercialization of inventions relating to skills: PEU_U01 A student is able to design a prototype of a finished product and conduct inventive sessions. PEU_U02 A student is able to generate conceptual solutions based on heuristic and systematic methods PEU_U03 A student is able to develop a design concept into a finished product using CAD modeling relating to social competences: PEU_K01 A student understands the need for continuous self-improvement in the work of an engineer. PEU_K02 A student is able to use creativity in everyday work and draw inspiration from it to solve technical problems PEU_K03 The student is able to plan activities aimed at carrying out a full product development cycle based on the Inventive Engineering methodology.

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Methods and tools of inventive design	2
Lec2	Overview of the methodology of Inventive Engineering	2
Lec3	Product and service innovation assessment	2
Lec4	Forecasting the development of products and services - phase "For"	2
Lec5	Forecasting the development of products and services – phase "Model"	2
Lec6	Forecasting the development of products and services - phase Analyzes"	2
Lec7	Forecasting the development of products and services - phase "Transfer"	2
Lec8	Building inventive teams	2
Lec9	Heuristic and systematic knowledge acquisition	2
Lec10	Conceptual design using heuristic methods	2
Lec11	Conceptual design using systematic methods	2
Lec12	Development of the design concept in terms of TEES changes: technical and technological, economic, environmental and social	2
Lec13	Financing engineering - preparing a budget for the development and commercialization of inventions and raising funds for the development of inventions and their commercialization. Part 1	2
Lec14	Financing engineering - preparing a budget for the development and commercialization of inventions and raising funds for the development of inventions and their commercialization. Part 2	2
Lec15	Evaluation classes	2
	Total hours	**30**

Laboratory	**Number of**

		hours
Proj1	Overview of the organization and schedule of activities. Selection of a case study for further analysis	2
Proj2	Assessment of the innovation of the selected product or service	2
Proj3	Forecasting the development of the selected product or service – phase "For"and "Model"	2
Proj4	Forecasting the development of the selected product or service – phase „Analyzes" and "Transfer"	2
Proj5	Problem definition in the, context of effect and cause, conceptual design	2
Proj6	Heuristic and systematic knowledge acquisition	2
Proj7	Development of the design concept and its commercialization	2
Proj8	Evaluation of reports – final report note evaluation	1
	Total hours	**15**

TEACHING TOOLS USED
N1. traditional lecture with the use of transparencies and slides N2. problem discussion N3. case study N4. self study - preparation for project class N5. multimedia presentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEK_W01, PEK_W02, PEK_W03	Test
F2 (project)	PEK_U01, PEK_U02, PEK_K01, PEK_K02, PEK_K03	Project preparation evaluation, project defense
P=F1		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] S. Koziołek. Inventiveness Engineering. Methodology of designing innovative technical systems. Publishing house of Wrocław University of Technology, first edition. Wroclaw 2019. [2] T. Arciszewski, Inventive Engineering: Knowledge and Skills for Creative Engineers. Taylor&Francis, 2016. [3] W. J. J. Gordon, SYNECTICS. The Development of Creative Capacity. New York: Macmillan Publishing Co., Inc., 1961. **SECONDARY LITERATURE:** [1] S. Koziołek i T. Arciszewski, „Syntectical Building of Representation Space: a Key to Computing Education", w Computing in Civil Engineering, 2011, ss. 1–15. [2] L. Haines-Gadd, TRIZ For Dummies. Wiley, 2016.

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FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Modelowanie układów wielczłonowych**
Name of subject in English:	**Modeling of multibody systems**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~ **/ 2nd level**~~, uniform magister~~ **studies*, full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory /** ~~optional / university-wide~~*****
Subject code:	**ASM003006**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)				**60**	
Number of hours of total student workload (CNPS)				**150**	
Form of crediting				**Crediting with grade**	
For group of courses mark (X) final course					
Number of ECTS points				**5**	
including number of ECTS points for practical (P) classes				**3**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				**1.4**	

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of the theory of machines and mechanisms
2. Ability to analyze classical kinematics and kinetostatics
3. Elemental knowledge of solid modeling using CAD / CAE systems

SUBJECT OBJECTIVES

C1. Understanding of building discrete computational models of multibody systems
C2. Knowing and understanding the principles of research planning, taking into account working conditions (e.g. kinematic excitations, dynamic loads, loads - including mass loads) of multi-unit systems in computer systems dynamic analyzes
C3. Acquiring by the student the ability to critically evaluate the obtained results of simulation of machinery in computer systems of dynamic analysis

SUBJECT LEARNING OUTCOMES
relating to skills: PEU_U01 Ability to apply a professional computer system for simulation and dynamic analysis of multibody systems PEK_U02 The ability to model the load conditions and the nature of the mechanism's work and the ability to analyze the obtained results from the simulation of the operation of a multibody system PEK_U03 Ability to compute the kinematics and dynamics of selected groups of mechanisms relating to social competences: PEU_K01 acquiring the ability to take responsibility for the own work PEK_K02 acquires care for the aesthetics of the performed work, including projects and reports

PROGRAMME CONTENT		
Project		**Number of hours**
Proj 1	An introduction to the principles of building multibody models	2
Proj 2	Basics of modeling mechanisms in MD.Adams – modeling links, kinematic pairs, kinematic contrains and kinematic excitations	6
Proj 3	Basics of modeling mechanisms in MD.Adams – modeling loads, performing calculations and analysis of the results	6
Proj 4	The test of modeling a multibody system	4
Proj 5	Kinematic and kinetostatic analysis of linkage mechanisms - virtual models construction	4
Proj 6	Analysis of kinematic and dynamic properties of the linkage mechanism (project)	4
Proj 7	Gear meachnism analysis (fixed, planetary and differential) - building principles of virtual models	4
Proj 8	Analysis of kinematic and dynamic of gears (project)	6
Proj 9	Construction of spacial manipulator models for direct and inverse kinematics task	4
Proj 10	Simulation studies of spacial manipulator (project)	6
Proj 11	Building models of spatial systems - constraints, excitations, loads	6
Proj 12	Modeling and simulations of spatial systems (project)	6
	Total hours	**60**

TEACHING TOOLS USED	
N1.	self-study - preparation for the project
N2.	multimedia presentation
N3.	interactive whiteboard (calculations, drawings, descriptions)
N4.	project presentation
N5.	consultation and tutorials

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1	PEK_U01-PEK_U03 PEK_K01-PEK_K02	Evaluation of test
F2	PEK_U01-PEK_U03 PEK_K01-PEK_K02	The average of projects evaluation
$P = 0{,}2 \cdot F1 + 0{,}8 \cdot F2$		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Gronowicz A.: Podstawy analizy układów kinematycznych. Oficyna Wydawnicza PWr., Wrocław 2003.
[2] Frączek J., Wojtyra M.: Metoda układów wieloczłonowych w dynamice mechanizmów. Oficyna Wydawnicza
[3] Politechniki Warszawskiej, Warszawa 2007
[4] MD. Adams – Reference Manual, 2008.
[5] Haug E.J.: Computer Aided Kinematics and Dynamics of Mechanical Systems. Allyn and Bacon, Boston 1989
[6] Norton R., L.: Design of Machinery, An introduction to the synthesis and analysis of mechanisms of machines.
[7] WCB, McGraw-Hill, Boston, 1999.
[8] Shabana A. Ahmed: Computational Dynamics, . A Wiley-Interscience Publications, NewYork, 1994.

SECONDARY LITERATURE:

[1] Miller S.: Teoria maszyn i mechanizmów. Analiza układów mechanicznych. Oficyna wydawnicza PWr. Wrocław 1996.
[2] Waldron J., Kinzel G.; Kinematics, dynamics and design of machinery, John Wiley & Sons, Inc. New York, 1999

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Zał. nr 5 do ZW 16/2020

FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name of subject in Polish:	**Teoria i inżynieria niezawodności i eksploatacji**
Name of subject in English:	**Reliability and Maintenance Theory and Engineering**
Main field of study (if applicable):	***Advanced Solid Mechanics***
Specialization (if applicable):	**Mechanics of Materials (MM)**
Profile:	**academic /** ~~practical~~*****
Level and form of studies:	~~1st~~**/ 2nd level,** ~~uniform magister studies~~*****, **full-time** ~~/ part-time studies~~*****
Kind of subject:	**obligatory**~~/ optional / university-wide~~*****
Subject code:	**ASM003007**
Group of courses:	~~YES~~ **/ NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**30**			**15**	
Number of hours of total student workload (CNPS)	**90**			**60**	
Form of crediting	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade*	Examination-/ crediting with grade *	~~Examination~~ **/ crediting with grade***	Examination / crediting with grade *
For group of courses mark (X) final course					
Number of ECTS points	**3**			**2**	
including number of ECTS points for practical (P) classes				**1**	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0.6**			**0.6**	

*delete if applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Has a basic knowledge of design and testing of technical processes/systems
2. Has a basic knowledge in the field of applied mathematics
3. Has a basic knowledge in the field of spreadsheet using, e.g. Excel

SUBJECT OBJECTIVES
C1. The acquisition of the extended knowledge in the areas of maintenance management and dependability management of technical systems and their supporting systems. C2. The acquisition of the basic knowledge in the areas of basic methods, tools, techniques and materials used to solve complex engineering tasks in the field of reliability, maintenance, and risk management of technical systems. C3. Acquiring the ability to solve the real-life problems, which may affect the effective performance of technical systems. C4. Acquiring the ability to design operation and maintenance processes, taking into account the need to ensure the desired level of operational availability and financial efficiency.

SUBJECT EDUCATIONAL EFFECTS
relating to knowledge: **PEU_W01** A student has extended knowledge of the operation and maintenance, dependability and safety of technical objects/systems **PEU_W02** Learn about development trends in technology and organization of operation and maintenance of technical objects/systems relating to skills: **PEU_U01** Able to use the known methods and mathematical models to analyze and design reliable technical objects/systems **PEU_U02** Can make rational decisions in the aspect of technical systems operation and maintenance management performance relating to social competences: **PEU_K01** Is able to properly prioritize the implementation of the tasks specified by him or others **PEU_K02** Can work in a group. He can lead a small team by taking responsibility for the effects of his work

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec1	Introduction to reliability engineering. Reliability management systems	2
Lec2	Processes leading to damage and failures. Classification and causes of failures	2
Lec3	Reliability modelling of irreparable component. Characteristics and indicators of reliability. Physical and statistical interpretation of reliability indicators	2
Lec4	Reliability modelling of unrecoverable technical systems. Basic reliability structures	2
Lec5	Reliability modelling of unrecoverable technical systems. Complex reliability structures	2
Lec6	Stochastic processes in reliability. The Poisson process and the birth and death process	2
Lec7	Markov processes.	2
Lec8	Technical object operation and maintenance problems - the main terms and definitions. System of operation and maintenance and its models	2
Lec9	Maintenance strategies and operating and maintenance prevention. Potential for operation and maintenance	2
Lec10	Maintenance strategies – LCC, RCM, RBM	2
Lec 11	Introduction to safety and risk management in technical systems	2

Lec 12	Tools and methods of technical object/system failure analysis (FMEA/FMECA)	2
Lec13	Risk analysis methods (FTA, ETA, PHA, PSA, HAZOP)	2
Lec14	Costs in maintenance and operation process performance. Reliability – cost or profit?	2
Lec15	Evolution of the reliability and safety theories – trends in development	2
	Total hours	**30**

Form of classes - project		**Number of hours**
Proj1	Introduction to the project course. Reliability analysis of technical objects (e.g. evaluation of reliability/unreliability functions, failure intensity)	3
Proj2	The use of conformance tests to assess the reliability of technical objects	2
Proj3	Analysis of technical objects reliability structure, definition of optimal warranty period for the specified assumptions	2
Proj4	Maintenance strategy selection with taking into account economic and reliability criteria	2
Proj5	Repairman problem	2
Proj6	Technical object failure analysis with the use of FMEA method	2
Proj7	Maintenance analyzes. Impact of operational conditions on reliability parameters	2
	Total hours	**15**

TEACHING TOOLS USED	
N1.	multimedia presentation
N2.	personal computer, interactive whiteboard (calculations, drawings, descriptions)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P –concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Test
F2 (Project	PEU_U01 PEU_U02	Test
F3 (Project)	PEU_U01 PEU_U02 PEU_K01 PEU_K02	Active work during project activities
P=0.6*F1+0.3*F2+0.1*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1] Aven, T. Quantitative risk assessment: the scientific platform. New York: Cambridge University Press, 2011.
[2] De Almeida, A.T. Multicriteria and multiobjective models for risk, reliability and maintenance decision analysis. Springer, 2015
[3] Dhillon, B.S. Maintainability, maintenance, and reliability for engineers. Boca Raton: CRC/Taylor & Francis, 2006
[4] Frenkel, I.B., Karagrigoriou, A., Lisnianski, A. (eds.) Applied reliability engineering and risk analysis: probabilistic models and statistical inference. Chichester, West Sussex: Wiley, 2014.
[5] Jardine, A.K.S., Tsang, A.H.C. Maintenance, replacement, and reliability: theory and applications. Boca Raton : CRC Press/Taylor & Francis Group, 2017
[6] Nash, F.R. Reliability assessments: concepts, models and case studies. Boca Raton etc.: CRC Press/Taylor & Francis Group, 2016
[7] Stapelberg, R.F., Handbook of reliability, availability, maintainability and safety in engineering design. London: Springer Verlag London Limited, 2009.
[8] Verma, A.K., Srividya, A., Karanki, D.R. Reliability and safety engineering. London etc.: Springer-Verlag, 2016

SECONDARY LITERATURE:

[1] Jin, T. Reliability engineering and services. Hoboken : Wiley & Sons, 2019
[2] Nakagawa, T. Random maintenance policies. Springer Series in Reliability Engineering, 2014
[3] Werbińska-Wojciechowska, S. Technical System Maintenance. Delay-Time-Based Modelling, Springer, 2019
[4] Zio, E., Baraldi, P., Cadini, F. Basics of reliability and risk analysis: worked out problems and solutions. New Jersey etc.: World Scientific, 2011.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)

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