FACULTY OF CIVIL ENGINEERING

SUBJECT CARD

Name in English:	**Computational mechanics**
Name in Polish:	**Metody komputerowe**
Main field of study (if applicable):	***Civil Engineering***
Specialization (if applicable):	**Civil Engineering**
Level and form of studies:	**~~1st /~~ 2nd level*, full-time ~~/ part-time~~***
Kind of subject:	**obligatory / ~~optional / university-wide~~***
Subject code:	**CEB005362**
Group of courses:	**~~YES~~ / NO***

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	**15**		**30**		
Number of hours of total student workload (CNPS)	**30**		**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**		
including number of ECTS points for practical (P) classes			**2,0**		
including number of ECTS points for direct teacher-student contact (BK) classes	**0,5**		**1,1**		

* delete as appropriate

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES
1. The student has extended knowledge of linear algebra and analysis as a base of structural analysis.
2. The student has knowledge of structural mechanics, strength of materials and theory of elasticity.
3. The student has basic knowledge of computational methods.

SUBJECT OBJECTIVES	
C1.	Presentation of energy functionals as a base of computer methods formulation (FEM).
C2.	FEM algorithm presentation for thin plate.
C3.	Presentation of finite elements used in plates and shells analysis.
C4.	Presentation of FEM in geometrically nonlinear and dynamic problems.
C5.	FDM extension for thin plates.
C6.	Presentation of BEM algorithm.
C7.	To set skills of error estimation, results interpretation and verification of computational methods.

SUBJECT EDUCATIONAL EFFECTS	
Relating to knowledge:	
PEK_W01	The student knows theoretical bases of computer algorithms for complex civil engineering structures analysis.
PEK_W02	The student knows FEM discrete modeling techniques for civil engineering structures.
PEK_W03	The student knows FDM algorithm for thin plates.
PEK_W04	The student knows theoretical basis of BEM.
Relating to skills:	
PEK_U01	The student is able to build plate, shells and complex shell-beam FEM discrete models.
PEK_U02	The student uses advanced FEM software dedicated to civil engineering structures analyses.
Relating to social competences:	
PEK_K01	The student is responsible for results reliability and correct interpretation of solution.
PEK_K02	The student has a conviction about necessity of knowledge continuous extension in field of contemporary software dedicated to civil engineering structures analyses.

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours**
Lec1	Introduction. Computer methods classification.	1
Lec2	Linear theory of elasticity variational formulation. Basis of variational calculus. Energy functionals in theory of elasticity: Lagrange, Reissner, Hu-Washizu.	2
Lec3	Lagrange functional for thin plate – FEM algorithm.	2
Lec4	Finite elements for plates modelling: compatible and incompatible rectangular elements.	2
Lec5	Triangular incompatible element. Flat triangular shell element.	2
Lec6	FEM in geometrically nonlinear problems. Nonlinear equilibrium equation. Buckling analysis.	2
Lec7	BEM algorithm for plane problems.	2
Lec8	FEM in structural dynamics.	2
	Total hours	**15**

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

Form of classes - laboratory		**Number of hours**
Lab1	Initial information. Introduction to FEM software used during course.	2
Lab2	Presentation of FEM software to simple problems of theory of elasticity – plate static and buckling analysis.	2
Lab3	Presentation of FEM software to simple problems of theory of elasticity – comparison of bending and membrane shell theories.	2
Lab4	Students own FEM modelling – geometrical model.	2
Lab5	Students own FEM modelling (cont.) – discrete model.	2
Lab6	Students own FEM modelling (cont.) –model solution, results presentation and interpretation.	2
Lab7	FDM for thin plates. Finite difference operators. Boundary conditions.	2
Lab8	FDM for thin plates. Examples.	2
Lab9	Students own FDM calculations.	2

Lab10	FEM in geometrically nonlinear problems.	2
Lab11	FEM in plane problem. Algorithm of global matrix equations assembling. Nodal parameters derivation. Support reactions calculation.	2
Lab12	Test part 1 – practical computer test with FEM software.	2
Lab13	Test part 2 – FDM task.	2
Lab14	Test for lecture.	2
Lab15	Second time to improve one's marks.	2
	Total hours	**30**

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

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

TEACHING TOOLS USED	
N1.	Lecture: traditional form.
N2.	Laboratory: multimedia presentations, FEM software, traditional form.
N3.	Office hours.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P (laboratory)	PEK_W02, PEK_W03, PEK_U01, PEK_U02, PEK_K01, PEK_K02.	student own modelling with FEM software, test
P (lecture)	PEK_W01, PEK_W02, PEK_U01, PEK_K01, PEK_K02.	test

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

1. O. C. Zienkiewicz, R. L. Taylor, J. Z. Zhu, The Finite Element Method, Sixth Edition, McGraw-Hill 2005.
2. Bathe J-K., Finite Element Procedures, Part 1-2, Prentice Hall 1995.
3. Banerjee P. K., Butterfield R., Boundary element methods in engineering science, McGraw-Hill 1981.

SECONDARY LITERATURE:

1. C. A. Brebbia, J. C. F. Telles, L. C. Wrobel, Boundary Elements Techniques, Springer-Verlag, Berlin 1984.
2. Washizu Kyuichiro, Variational methods in elasticity and plasticity, Pergamon Press, 1982.

SUBJECT SUPERVISOR (NAME AND SURNAME, DIVISION, E-MAIL ADDRESS)
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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
Computational mechanics
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY ***Civil Engineering***
AND SPECIALIZATION **Civil Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**	Subject objectives ***	Programme content ***	Teaching tool number ***
Knowledge				
PEK_W01	K2_W01, K2_W02, K2_W03, K2_W09, K2S_CEB_W16	C1, C6	Lec2, Lec7	N1, N3
PEK_W02	K2_W03, K2_W05, K2_W09	C2, C3, C4	Lec3 ÷ Lec6, Lec8, Lab11	N1, N2, N3
PEK_W03	K2_W01, K2_W02, K2_W04, K2_W05, K2_U16	C5	Lab7 ÷ Lab9	N2, N3
PEK_W04	K2_W01, K2_W02, K2_W05	C6	Lec7	N1, N3
Skills				
PEK_U01	K2_U02, K2_U04, K2_U07, K2_U08, K2S_CEB_U19	C2, C3, C4, C7	Lab1 ÷ Lab6, Lab10	N2, N3
PEK_U02	K2_U02, K2_U06, K2_U08, K2_U09, K2S_CEB_U19	C2, C3, C4, C7	Lab1 ÷ Lab6, Lab10	N2, N3
Social competence				
PEK_K01	K2_K04	C7	Lab2, Lab3, Lab6, Lab10	N2, N3
PEK_K02	K2_K01	C4, C6	Lec1, Lec6 ÷ Lec8, Lab10	N1, N2, N3

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above