

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	
<u>PRIMARY LITERATURE:</u>	
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.
<u>SECONDARY LITERATURE:</u>	
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