GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Non-linear Analysis of Structures , PG_00041316		
Field of study	Civil Engineering		
Date of commencement of studies	February 2025	Academic year of realisation of subject	2025/2026
Education level	second-cycle studies	Subject group	Optional subject group Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	2	ECTS credits	4.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Structural Mechanics Department -> Faculty of Civil and Environmental Engineering		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Ireneusz Kreja	
	Teachers		

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	15.0	15.0	0.0	0.0	60

E-learning hours included: 0.0

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	60	5.0	35.0	100

Subject objectives

Students acquire the basis knowledge on the Non-linear Analysis of Structures

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W03] has knowledge of Continuum Mechanics, knows rules of static analysis, stability and dynamics of complex rod, shell and volume structures, both in linear and basic nonlinear regime	Student explains fundamental concepts of non-linear continuum mechanics; she/he names basic strain and stress measures and general laws of conservation. Student describes classical models of materials. She/he explains the essence of materially non-linear problems using the example of elastic-plastic analysis.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
[K7_U04] is able (using Finite Element Method), to define a calculation model and to perform advanced numerical analysis of complex constructions in: linear range and elementary nonlinear range, can criticaly evaluate the results of calculations.	Student is able to perform a simple structural analysis in the range of geometrical and/or material non-linearity. Student identifies sources of nonlinearity in structural analysis, she/ he recognizes geometrical and material non-linearity.	[SU1] Assessment of task fulfilment [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task
[K7_W04] has knowledge on advanced strength of materials, modeling and optimisation of materials and constructions; has knowledge of fundamentals of Finite Element Method and general nonlinear analysis of engineering constructions and systems	Student depicts basic idea of incremental description of motion and incremental/iterative techniques for solving non- linear problems. She/he classifies modes of stability loss and types of bifurcation points. Student recognizes path tracing techniques.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects

<table>
<tr><td>Subject contents</td><td>LECTURES:
Sources of non-linearity in structural analysis, geometrical and physical non-linearity.
Basics of non-linear continuum mechanics: Description of motion and deformations. State of stress. General laws of conservation in mechanics. Principle of virtual work. Constitutive models.
Incremental description of motion. Total Lagrangian and Updated Lagrangian descriptions. Incremental/ iterative techniques for solving non- linear problems. Large deformation of elastic truss structures. Stability problems and post-buckling behaviour of structures. Path tracing techniques. Material non-linearity in small and large deformation analysis of structures. Elastic-plastic analysis.
Selected examples of non-linear analyses of structures.
Remarks on non-linear analysis of dynamic problems.
TUTORIALS:
Application of available computer programs to perform:
1) geometrically non-linear analysis of truss structure
2) elastic-plastic analysis of 2D problem.
Presentation of obtained results in a form of two project reports to be graded.</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Course "Theory of Elasticity and Plasticity" should be completed.
It is recommended to take part in the courses "Finite Element Method" and "Stability of structures".</td></tr>
<tr><td>Assessment methods and criteria</td><td><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Three project reports</td><td>0.0%</td><td>60.0%</td></tr>
<tr><td>Written test</td><td>0.0%</td><td>40.0%</td></tr>
</table></td></tr>
<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>1. M. Kmiecik, M. Wizmur, E. Bielewicz: Analiza Nieliniowa Tarcz i Płyt, Wydawnictwo Politechniki Gdańskiej Nr 695/79, Gdańsk 1995 (in Polish)
2. Z. Waszczyszyn, Cz. Cichoń: "Podstawowe wiadomości o nieliniowej analizie konstrukcji", rozdział w Mechanika budowli, ujęcie komputerowe, tom 3, Arkady, Warszawa 1995, str. 193-253.(in Polish)
3. Z. Waszczyszyn, Cz. Cichoń, M. Radwańska: Stability of Structures by
Finite Element Methods, Elsevier, Amsterdam 1994</td></tr>
<tr><td>Supplementary literature</td><td>1. K.-J. Bathe: Finite Element Procedures, Prentice Hall Inc., New Jersey 1996.
2. J. Bonet and R. D. Wood: Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, New York 1997.
3. M. Crisfield: Non-linear Finite Element Analysis of Solids and Structures, Vol. 1: Essentials, J. Wiley & Sons, New York 1991.
4. M. Kleiber: Metoda Elementów Skończonych w Nieliniowej Mechanice Kontinuum, PWN, Warszawa-Poznań 1985 (in Polish)
5. M. Kleiber (ed.): Komputerowe Metody
Mechaniki Ciał Stałych, seria "Mechanika Techniczna", tom XI, Wyd. Naukowe PWN, Warszawa 1995 (in Polish)
6. A. Sawicki: Mechanika Kontinuum, Wprowadzenie, Wyd. IBW PAN, Gdańsk 1994 (in Polish)</td></tr>
<tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr>
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<tr><td>Example issues/ example questions/ tasks being completed</td><td>Exemplary questions at the final test:
1) Sketch a non-linear equilibrium path for a given example
2) Explain a difference between the Lagrange and Euler description of body motion
3) What are differences between the given deformation(stress) measures?
Projects:
1) Present a numerical solution of a given non-linear problem with a use of spreadsheet
2) Apply a chosen FEM package to perform a large elastic displacement analysis of a given plane truss structure. Present appropriate equilibrium paths, check an imperfection sensitivity of the structure, categorize the obtained response according to the classification given in a lecture.
3) Apply a chosen FEM package to perform a large deformation analysis of a given plane problem, assuming: a) elastic, b) elastic-plastic, and c) elastic-plastic with strain hardening material model. Compare obtained equilibrium paths for all 3 cases. Present the established development of plastification zones.</td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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