THE DOCTORAL SCHOOL OF IPPT PAN

COURSE OFFERED IN THE DOCTORAL SCHOOL OF IPPT PAN

Name of the course	Polish	**Programowanie, Numeryka i Optymalizacja**				
	English	**Programming, Numerics and Optimization**				
Type of the course	**Specialized course**					
Course coordinator	**Łukasz Jankowski**		Course teacher	**Łukasz Jankowski**		
Implementing unit	**ZTI**	Scientific discipline / disciplines	**Information and communication technology**			
Level of education	**Doctoral studies**	Semester	**Summer or winter**			
Language of the course	**English or Polish**					
Type of assessment	**Homework**	Number of hours in a semester	**30**	ECTS credits	**3**	

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	**2**	**0**	**0**	**0**	**0**
	in a semester	**30**	**0**	**0**	**0**	**0**

1. Prerequisites

Basic literacy in programming, numerics, and mathematics, as expected from all graduates of M.Sc.Eng. level studies

2. Course objectives

1. Introducing the principles of numerical computations (conditioning, stability, etc.) and selected numerical techniques for linear systems, ordinary differential equations and optimization (including structural optimization).

2. Providing a foundation for implementing some of these techniques in any programming language (C++ is used within the course).

3. Course content (separate for each type of classes)

Lecture

- Preliminaries, programming basics I, II and III
- Object-oriented programming
- Basics of numerical computations
- Numerical integration of ODEs
- Linear systems I and II
- Linear integral equations
- Basics of optimization
- Unconstrained optimization I and II
- Constrained optimization
- Structural reanalysis in statics
- Heuristic methods

Laboratory
n/a

4. Learning outcomes			
Number of the learning outcome	Learning outcomes description	Reference to the learning outcomes according to the 8th level of PRK	Learning outcomes verification methods*
Knowledge			
1	The graduate acquires basic knowledge in numerical computations and selected numerical techniques for linear systems and ordinary differential equations	P8S_WG	homework evaluation / project evaluation
2	The graduate acquires basic knowledge in optimization methods and techniques (including structural optimization)	P8S_WG	homework evaluation / project evaluation
3	The graduate knows how to transfer the acquired knowledge to the industrial sphere and disseminate the results of his research	P8S_WK	active participation during classes
Skills			
1	The graduate is prepared for implementing many numerical and optimization techniques in any programming language	P8S_UW	homework evaluation / project evaluation
2	The graduate is able to solve common problems in numerical techniques for linear systems, ordinary differential equations and (structural) optimization.	P8S_UW	homework evaluation / project evaluation
3	The graduate is able to identify common pitfalls of frequently used numerical functions of mathematical and engineering software packages, and, as a result, he/she is able to use these functions more consciously and less in a black-box manner.	P8S_UW	homework evaluation / project evaluation / active participation during classes
4	The graduate is able to develop customized solutions for problems that are too large, too fine or that run too slow to be solved using standard functions of typical mathematical software packages.	P8S_UW	homework evaluation / project evaluation
Communication			
1	The graduate is able to clearly describe and discuss the outcomes of his/her creative work and the encountered difficulties	P8S_UK	homework evaluation / project evaluation / active participation during classes
Social competences			
1	The graduate is ready to critically assess and discuss the outcomes of his/her creative work	P8S_KK	homework evaluation / project evaluation / active

			participation during classes
2	The graduate is ready to creatively solve encountered problems and challenges	P8S_KO	homework evaluation / project evaluation / active participation during classes

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria

Final grade is based on the examination in the form of homework assignments/projects

6. Literature

Primary references:

[1] Eckel, B. (2000). Thinking in C++ (2nd ed., Vol. 1). Prentice Hall.

[2] Eckel, B. (2003). Thinking in C++ (2nd ed., Vol. 2). Prentice Hall.

[3] Gręboszc, J. (2015). Symfonia C++ Standard. Editions 2000 Kraków (in Polish). [or the subsequent "Opus magnum C++11 / Misja w nadprzestrzeń C++14/17"]

[4] Dahlquist, G., & Björck, Å. (2008). Numerical methods in scientific computing: Vol. 1. Society for Industrial and Applied Mathematics. [and the subsequent Vol. 2, 2010]

[5] Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2002). Numerical recipes in C++: The art of scientific computing (2nd ed.). Cambridge University Press.

[6] Nocedal, J., & Wright, S. J. (2006). Numerical optimization (2nd ed.). Springer.

Secondary references:

[7] Wirth, N. (1976). Algorithms + data structures = programs. Prentice-Hall.

[8] Golub, G. H., & Van Loan, C. F. (2013). Matrix computations (4th ed.). Johns Hopkins University Press.

[9] Haftka, R. T., & Gürdal, Z. (1992). Elements of structural optimization (3rd ed.). Springer.

7. PhD student's workload necessary to achieve the learning outcomes**

No.	Description	Number of hours
1	Hours of scheduled instruction given by the lecturer in the classroom	**30**
2	Hours of consultations with the lecturer, exams, tests, etc.	**15**
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	**40**
4	Amount of time devoted to the preparation for exams, test, assessments	
	Total number of hours	**85**
	ECTS credits	**3**

** 1 ECTS = 25–30 hours of the PhD students work (2 ECTS ≈ 60 hours; 4 ECTS ≈ 110 hours, etc.)