Załącznik Nr 1
do zarządzenia Nr 182/2023
z dnia 21 lipca 2023 r.

SYLLABUS FOR THE DOCTORAL SCHOOL

Lp.	Syllabus elements	Description
1	Course/module name in Polish and English	Zaawansowane metody numeryczne Advanced numerical methods
2	Scientific discipline	Mathematics
3	Name of organizational unit organizing education	Doctoral College of Mathematics
4	Unit conducting the course/module	Institute of Mathematics
5	Course/module code	--
6	Type of course/module	Optional
7	Year of studies	Open for all
8	Semester	Summer
9	Forms and methods of instruction	Lecture + labolatory
10	Educational contents	Approximation theory is an established field, and my aim is to teach you some of its most important ideas and results, centered on classical topics related to polynomials and rational functions. The style of this book, however, is quite different from what you will find elsewhere. Everything is illustrated computationally with the help of the Chebfun software package in Matlab, from Chebyshev interpolants to Lebesgue constants, from the Weierstrass approximation theorem to the Remez algorithm. Everything is practical and fast, so we will routinely compute polynomial interpolants or Gauss quadrature weights for tens of thousands of points. In fact, each chapter of this book is a single Matlab M-file, and the book has been produced by executing these files with the Matlab "publish" facility. Beginners are welcome, and so are experts, who will find familiar topics approached from new angles and familiar conclusions turned on their heads. Indeed, the field of approximation theory came of age in an era of polynomials of degrees perhaps O(10).

Now that O(1000) is easy and O(1,000,000) is not hard, different questions come to the fore. For example, we shall see that "best" approximants are hardly better than "near-best", though they are much harder to compute, and that, contrary to widespread misconceptions, numerical methods based on high-order polynomials can be extremely efficient and robust.

In other words: We will discuss the practical and theoretical aspects of approximating and interpolating functions, using high-order polynomials, trigonometric series, and rational functions. These ideas, which form the basis for spectral methods, will then be applied to solving some differential equations.

Topics of the course:

- Myths of polynomial interpolation and integration
- Fast Fourier Transform and pseudo spectral methods
- Polynomial Roots and Colleague Matrices
- Weierstrass and Bernstein Approximation
- Chebyshev, Legendre series and best Approximations
- Orthogonal polynomials - Clenshaw-Curtis and Gauss quadrature
- Runge's phenomenon (overfitting) - Lebesgue constants
- Approximation errors of Chebyshev and Legendre interpolation
- Approximation errors of Clenshaw-Curtis and Gauss quadrature
- Spectral differentiation and non-periodic ODEs & PDEs

11	Language of instruction	English
12	Intended learning outcomes regarding: Knowledge: knows theoretical aspects of the Fourier transform, knows fundamental properties of orthogonal polynomials and interpolation methods, knows theorems on best approximations, knows numerical methods for solving mathematical tasks, knows selected approximation methods and their possible applications Skills: can evaluate errors in selected approximations methods, can adapt approximation methods for formulated practical problem, can use software for solving approximation problems and interpret results Social competences: can formulate and solve practical problems (e.g. from physics, demography economy) and use numerical methods for solving, Understands the need for constant education and learning about new achievements in the field of approximation	Symbols of learning outcomes: SD_W01, SD_W02 SD_U01, SD-U02, SD_U03, SD_U05, SD_U07 SD_K01, SD_K02
13	Methods of verifying intended learning outcomes	Discussions during problem session, presentation of an assigned topic, written report about assigned subject, examination
14	PhD student's workload	
	PhD student's activity form	Average number of hours for completing the activity
	Numbers of class hours (according to the study plan) with teacher: - Lecture: - Problem sessions: - Laboratory: - Seminar:	 30 30

	- Others:	
	PhD student's own work, such as: - Preparing classes: - Developing results: - Reading the suggested literature: - Writing a class report: - Preparing for exam: - Others:	
	Total hours:	
	Number of credits (if required)	
15	Conditions for crediting the course/module, including the rules for admitting to the exam, and the form and conditions for crediting individual forms of classes included in the given course.	50% of all exercices have to be solved / final project will be graded In lieu of a final exam, students will complete a final project consisting of a written report (5-10 pages) and oral presentation (15 minutes) on a topic related to the course. The purpose of the project is to explore some topic we cover or discussed in the book in more detail and then to teach the other students about it.
16	Literature	L. N. Trefethen, Approximation Theory and Approximation Practice (ATAP), SIAM 2013. G. F. Carrier, M. Krook, and C. E. Pearson, Functions of a Complex Variable: Theory and Technique, SIAM Classics in Applied Math Series. T. A. Driscoll, Learning MATLAB, SIAM 2009. Available as an e-book from the library. Highly recommended for those not familiar with MATLAB. M. J. Ablowitz and A. S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press, 2003.

		Chapters 2-4 provide a good review (introduction). B. Fornberg, A Practical Guide to Pseudospectral Methods, Cambridge University Press 1996. Straightforward, to the point, and practical! J. P. Boyd, Chebyshev and Fourier Spectral Methods, Dover 2001.

* wykład, seminarium, ćwiczenia, warsztaty, lektoraty, laboratoria
** prezentacja, projekt, analiza przypadku, dyskusja, metoda problemowa
*** stacjonarnie/zdalnie