Doctoral program

(1) Short Description of the PhD program in Mathematics and Computer Science

Independent research activity is the most important part of the PhD program. Each PhD student has a unique PhD supervisor who is fully responsible for directing and helping the student's activities, including the selection of the subjects to be studied, the research work, the publication of the results and the preparation of the PhD thesis work. During the admission procedure, it is the responsibility of the supervisor to ensure that only students who can be expected to meet the requirements of the course are admitted to the PhD program. Two supervisors are permitted only in the case of interdisciplinary research or in the framework of an international cooperation – in these cases a prior permission is required, given by the Doctoral Council of the Doctoral School (DC) and approved by the Doctoral Council of the University (DCU). If the research activity is part of a cooperation agreement between the Doctoral School and a research institute of the Hungarian Academy of Sciences and therefore the supervisor is not a university staff member then the DC assigns an internal consultant as well.

During the PhD program the student must ***study*** various subjects. They may choose among the doctoral courses announced for the semester in BME. No credit is awarded for the completion of basic BSc subjects in mathematics. In the case of interdisciplinary research, a request must be submitted to DC before the start of the current semester, for taking other thematic subjects (e.g. physics, chemistry, etc., even at BSc level). PhD level courses offered by other universities can also be selected with the prior permission of the DC. Most of these „study" credits should be collected in the ***first phase*** (during the first four semesters) of the program. Further credits can be collected in the ***second phase*** (during the last four semesters) as well, mostly by participating at international „summer schools" or other intensive scientific activities. See Chapter 2 for information on credits for attending summer schools.

The student must also participate in the ***teaching*** activity at the university in order to enhance his/her lecturing and communicating abilities, under the guidance of a designated lecturer . The subjects to be taught and the credits for these are determined by the head of the supervisor's department - in consultation with the supervisor The completion of the course is certified by the head of the department on the recommendation of the designated lecturer.

An essential part of the program is the regular ***consultation*** betwen the student and the supervisor, to help the research and publication activities of the student. The level and effectiveness of these consultations are graded by the supervisor. A necessary condition of receiving credits for this activity is to present the student's results at the PhD conference of the Doctoral School. The day of the PhD conference is set by the DC, and usually takes place in the third semester of the course in September.

Most of the „research" credits, however, should be obtained by ***publishing*** the student's results in international scientific research journals and presenting them at international **conferences**, especially during the second phase of the program. Further credits can be granted for research performed at partner institutions in case of international research agreements.

By giving credits for publication activity, the supervisor acknowledges that obtaining all publication credit points during the training meets the minimum requirement for obtaining a degree by the end of the eighth semester.

(2) Professional competencies to be acquired

Our goal is that a mathematician holding a PhD degree possess the competencies detailed below

a) knowledge

The PhD student knows the general laws of mathematics at system level and in various relationships.

Acquired in depth (researcher level) knowledge of the subject, general and specific characteristics, major trends and limits, and the relationships – both settled and disputed ones – of his/her discipline.

Adapts an analytic and understanding approach while continually contributing to the fiducial knowledge in the international literature.

Acquired the required level of knowledge in informatics and mathematics to creatively apply them to manage, evaluate and publish his/her own research data and results.

Acquired the research methodology knowledge required for individually conducting research his/her own discipline.

Acquired in depth knowledge and understands the relationships, theories and underlying concepts and nomenclature required by their creative application.

b) skills and capabilities

Apt to independently plan and implement new projects and work phases in his/her discipline.

Capable of performing creative analyses within his/her own discipline, formulating and modelling comprehensive and specific relationships in a novel, synthetic way, and performing evaluations and criticism.

Apt to apply and improve the learning and problem-solving methods characteristic of his/her discipline.

Apt to creatively connect information from unrelated or loosely connected fields and explore inherent relationships between them. Meanwhile, the PhD student is capable of recognizing and highlighting significant and crucial aspects in the creative process of evaluating the research results.

Apt to realistically and critically analyse and evaluate his/her own as well as others' results on strictly professional ground and treat them according to their true vale.

Apt to critically handle mathematics related information and news and contributes to professional disputes with arguments based on expertise.

Apt to transfer knowledge at the adequate level both to professionals of his/her own field and to others, and to participate in professional arguments and discussions.

Capable of oral and written expert communication and professional cooperation both in domestic and international relations.

Capable of summarizing, presenting and transferring his/her knowledge and research achievements in his/her academic discipline. The student is familiar with the publication methods of his/her field and is capable of practicing them on his/her own (e.g., independent authoring of articles, books, academic works).

c) attitude

S/he is creative, flexible and intuitive, works systematically, decision making, and problem identification and solving skills.

Strives to identify and conceptualize scientific problems yet unexplored and unsolved.

Has a strong professional commitment and accepts the need for persistent work.

Open to learn newly developing research areas.

S/he thinks open-minded and exempt from professional preconceptions in the course of problem solving and model creation.

Realistically and yet emphatically evaluates professional achievements and performances pertaining to his/her own and his/her team members' work.

Accepts fair professional critics and other's professional arguments.

Open and committed to participate in professional cooperation or initiate them both in domestic and international relations.

d) autonomy and responsibility

Capable of elaborating comprehensive and special professional problems, representing professional opinions and arguing for them autonomously in the field of modern mathematics.

S/he takes a peer discussion partner role in disputes with professionals in his/her own scientific discipline.

(3) Recommended Schedule of the Credit Program for the Eight Semesters

Type of the credits	**total # credits first phase + second phase**	**1st semester**	**2nd semester**	**3rd semester**	**4th semester**	**5th semester**	**6th semester**	**7th semester**	**8th semester**
		first phase of the program				second phase of the program			
Study	25+5	8	6	6	5	5			
Teaching	12 + 12		4	4	4	4	4	4	
Research 1 (consultation)	64 +64	16	16	16	16	16	16	16	16
Research 2 (publishing)	20 +30		5	5	10	5	10	10	5
Research 3 (thesis writing)	0 + 8							4	4
Total	**120+120**	**24**	**31**	**31**	**35**	**30**	**30**	**34**	**25**

There is flexibility to deviate from the recommended schedule, but the following rules must be followed during training:

- Completion of a total of at least 120 credits up to the end of the semester of the complex examination (end of the study period), including at least 25 study credits

- A minimum of 15 credits per semester

- Maximum of 45 credits per semester in the first two years and 60 credits in the second two years (not counting the accredited credits

- Completion of at least 240 credits in total

The minimum and maximum values of the credits in each group are given in the following table:

Study	25-40 credits
Teaching	20-32 credits
Research 1 (consultation)	80-128 credits
Reseach 2 (publishing)	40-80 credits
Research 3 (thesis writing)	0-8 credits

Concerning "**Study**" credits – in justified cases - the supervisor may also announce a reading course for the doctoral student - for 3 credits per course. These „reading courses" need to be registered in the Neptun system, and other doctoral students are also eligible to take these courses. During the reading course, the supervisor assigns a topic that the doctoral student will learn from books, with the help of occasional consultations. The course ends with an exam. The total number of credits obtained for reading courses - in the period before the complex exam - may not exceed 12.

Credits for attending summer schools have to be certified by the head of the Doctoral School on the basis of an individual assessment. A maximum of 5 credits in total can be completed in summer schools. One week of summer school can be awarded 2 credits and two weeks of summer school can be awarded 3 credits.

Concerning "Research 1" subjects, a maximum of 4 credits per semester can be given for seminar participation, 4 credits for conference participation (even without giving a lecture), and twice 4 credits for consultation with the supervisor.

The necessary condition for obtaining the minimum 80 credits is that the student has to participate in at least one scientific seminar - in at least 6 of the 8 semesters, in consultation with the supervisor (e.g. BME, ELTE, Rényi Institute, or any other high-quality seminar). Credits are given by the supervisor, it is the supervisor's responsibility to check the participation of the student in the seminar.

Concerning "Research 2" subjects a maximum of 5 credits per semester can be given for a conference or seminar presentation or a conference poster, and a maximum of 5 credits per semester can be given for publication activities (partial or full publication).

In the **teaching activity**, during the PhD program, the student can obtain a total of 4 credits (with the approval from the head of the department) for grading midterm exams or homework assignments, for consultation, or for activities promoting the university. Additional teaching credits can only be obtained with the following teaching activities:

- 4 credits can be acquired for teaching 2 contact lessons per week
- 4 credits can be acquired for 2 hours study room supervision per week / assisting study group for 2 hours per week

It is the responsibility of the supervisor and the head of the department to ensure that the PhD student is assigned to a teaching task that he or she can perform at an appropriate level.

After the first year of training, PhD students give a 20-minute presentation on the scientific results obtained in the first year of the programme. The DC assesses the progress made and provide the students with any recommendations.

(4) Comprehensive Examination

DC checks if the students meets the assumptions of the complex exam. The minimum requirement is as follows: until the the semester of the complex exam the students must obtain all the study credits and at least 90 credits in total. This does not apply for those who prepare individually for the PhD. Those who choose the way of individual preparation, must fulfill the numerical parameters of the complete publication requirement of the PhD before they apply for

the complex exam. Those who choose the way of individual preparation become PhD students only when their application for the Comprehensive Examination gets accepted by the DC.

The Comprehensive Examination is a public exam in front of a committee, consisting of at least three members where at least one third of the members are external (not employed by the university). The chair of the committee must be a regular or emeritus professor, or must possess the degree „Doctor of the Hungarian Academy of Sciences". The student's supervisor is a nonvoting member of the committee and must prepare a detailed evaluation of the performance of the student. This evaluation must be submitted in electronic form to the chair of the committee at least one week before the exam.

The exam consists of two parts. The „theory part" evaluates the knowledge of the student in two areas of mathematics. The list of the possible areas is given in Chapter (5) below and is also available at the home page of the Doctoral School. The „dissertation part" evaluates the state of the student's research activity. In this part the student describes his knowledge in the relevant literature, his new scientific results obtained so far, his planned schedule for publication and thesis writing during the next four semesters. During his/her lecture the student must evaluate the significance of the research and, if applicable, the practical applicability of the results. The short summary of the results and the list of the (submitted, accepted or published) articles must be submitted in electronic form to the chair of the committee at least one week before the exam. The Comprehensive Examination can be successful only if the students has at least one publication which has at least been submitted for publication and publicly available (like on the arXive: https://arxiv.org/).

Each member of the exam committee separately evaluates both parts of the exam. The exam is successful if the majority of the committee members find both parts successful. Otherwise the unsuccessful exam can be repeated at most once during the exam period of the actual semester. An official written report must be prepared about the exam. The student should be informed about the result of the exam in the same day. The grade of the complex exam does not influence the qualification level of the PhD title but the successful exam is a prerequisite of entering the second phase of the doctoral program.

(5) Subjects of the „Theory Part" of the Comprehensive Examination

The subjects of the exam must be selected from the list below. Two distinct ***groups*** should be selected at first, then the student may select any pair of ***topics*** within both groups. The final selection must be approved by the DC. The detailed content of each topics is available in the homepage of the Doctoral School.

Name of the group	Topics within the group
Algebra and Logics	Group Theory, Group Representations, Semigroups and Automata, Ring Theory, Commutative Algebra and Algebraic Geometry, Field Theory and Linear Algebra, Universal Algebra and Lattice Theory, Model Theory and Algebraic Logic, Proof Theory and Its Applications, Non-Classical Logics in Computer Science.
Analyis	Measure and Integral, Operator Algebras, Matrix Analysis, Complex Analysis, Fourier Analysis, Functional Analysis, Linear Systems, Approximation Theory, Numerical Methods
Differential Equations	Ordinary Differential Equations, Partial Differential Equations, Numerical Methods of Differential Equations
Discrete Mathematics and Computer Science	Combinatorial Analysis and Graph Theory, Matroid Theory, Combinatorial Optimization, Data Structures, Computational Models, Machine Learning, Data Mining and Its Applications
Geometry	Spline Modelling of Surfaces, Algorithms of Computational Geometry, Lattice Geometry, Crystal Geometry, Non-Euclidean Geometries, Combinatorial Geometry, Differential Geometry, Riemannian Geometry
Number Theory	Combinatorial Number Theory, Additive Number Theory, Analytic Number Theory, Modular Forms, Class Field Theory, Cryptographic Applications of Number Theory
Operations Research	Linear Programming, Nonlinear Programming, Stochastic Programming
Stochastics	Foundations of Probability Calculus, Martingals and Limit Theorems, Random Walks and Markovian Chains, Stationary Processes, Stochastic Analysis, Information Theory, Basic Concepts of Statistics and Estimation Theory, Hypothesis Testing, Multivariable Analysis

(6) Research Areas

- algebra and logic
- number theory
- analysis
- differential equations
- numerical methods
- operations research and its applications
- applied mathematics
- geometry
- discrete mathematics and computer science
- stochastics
- Data Science
- Dynamical Systems and Fractal Geometry

(7) Description of the Main Research Areas of the Departments

Department of Algebra and Geometry

The algebra group:

The main topics of the scientific research of the Algebra group are: algebraic and mathematical logic, automata theory, algebraic and arithmetical algorithms, group theory, computer algebra, semigroup theory, universal algebras, quasigroups, matrices, computer science, finite geometries and their applications in criptography.

The Geometry group:

Besides the differential geometry problem group (with central areas being investigation of mathematical questions and spaces induced by quantum physics, and Thurston and Minkowski spaces), there is an intensive ongoing research on discrete and combinatorial problems (primarily convex geometry questions). The two main research directions are connected vie computer graphics (problems of graphical visualization).

Department of Analysis and Operation Research

The Analysis group:

Strong research groups work on several mathematical aspects of quantum mechanics (as the differential geometry of the state space, quantum information theory, random matrices, spectral theory of Schrödinger operators, inverse potential scattering), on the functional analysis (operator theory, operator algebras, operator semigroups), on Fourier analysis, on approximation theory (growth properties of polynomials of several variables, potential theory, Hermite-Fejer interpolation). Linear systems and reaction kinetics are also investigated.

The Differentialequations and Operation Research Group:

The group conducts research on three larger, separate, fundamentally applied areas of mathematics. In the area of differential equations most of the research is carried out regarding dynamical systems, ergodic theory, numerical dynamics, and bifurcation theory, as well as applications in biology, engineering and economics. The results achieved in operations research concern mostly the topics of linear optimization, convex optimization, semidefinite optimization, interior point methods, integer programming, stochastic modelling and programming, combinatorial optimization, global optimization, multiobjective optimization and its applications, applications in economics, stochastic time series models and applications in statistics. On the subject of numerical analysis, our colleagues focus on the numerical methods of ordinary and partial differential equations. The research goal is to develop accurate and fast numerical methods that provide numerical solutions corresponding to the qualitative properties of the modelled processes. Such results include, for example, specifying the conditions of discrete maximum principles for different finite element methods, superlinear Krylov convergence for streamline-diffusion finite element methods, variable quasi-Newton preconditioning for nonlinear problems, higher-order, reliable numerical methods for epidemic propagation models, examination of operator splitting methods, application of non-standard finite difference methods, and the combination of Richardson extrapolation with classical ODE solvers.

Department of Computer Science and Information Theory (Faculty of Electrical Engineering and Informatics)

The main focus is on discrete mathematics, mathematical foundation of computer science, number theory, information and coding theory, data mining, and their applications in engineering, in economics and in the development of cutting edge computer technologies

Department of Stochastics (Mathematical Institute, Faculty of Natural Sciences)

There are five active research groups at the Department of Stochastics:

Stochastic processes: On this field, there is an Academic Research Group at the Department. Research topics include: random walks, stochastic differential equations, percolation and complex networks.

Dynamical Systems: Billiards (dynamical systems with singularities), fractals and geometric measure theory.

Stochastic analysis: approximation of Brownian motions with random walks.

Statistics: we deal with both theory and applications of the mathematical statistics.

Data Science: The research is done in the frame of The Human and Social Data Science Lab (HSDSLab), which provides excellent opportunities for PhD students to learn into this very import field of research.

(8) Courses

The list of doctoral courses is available at the website of the Doctoral School https://doktori.math.bme.hu/english/index-E.html . The list of those courses which can be selected in a given semester is available in the Neptun Integrated Study Administration System . These regulations were discussed by the Doctoral Council of Doctotal School of Mathematics and Computer Science at the meeting of February 13, 2018, and accepted by the Doctoral Council of the BME at the meeting of February 22, 2018. For applications submitted before January 1, 2019, the Candidate may request the application of the previous requirements introduced in 2008. Both documents are available to everyone in the BME TTK Dean's Office and on the website of the Doctoral School.

Amended on February 23, 2021 at the online meeting of the Doctoral Council and Habilitation Committee of Mathematical Sciences, accepted by the BME Doctoral Council and Habilitation Committee meeting on February 25, 2021.

Amended on February 21, 2025 at the online meeting of the Doctoral School Council, the amended version was accepted by the BME EHBDT at the meeting on February 27, 2025.