Training Plan – SZTE Doctoral School of Mathematics

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1. Doctoral Training Programs

- Pure Mathematics
- Applied Mathematics
- Didactics of Mathematics

Within these, the main research areas cover algebra, analysis, dynamical systems, geometry, discrete mathematics, and stochastics.

2. Structure of the Doctoral Training

The doctoral training is fundamentally based on the **professional and trust-based relationship** between the doctoral student and the supervisor(s).

2.1. Doctoral Credits

The total number of credits to be earned during the doctoral training: **240.**

Before the official closure of each reporting period, the doctoral student prepares a **report** on the work completed for the Head of the Doctoral School, which is reviewed and signed by the supervisor.

At the Doctoral School of Mathematics, credits can be earned for **study**, **research**, and **teaching** activities as follows.

2.2. Study Credits

During the **first two years of the program**, the student must complete at least 5 courses, including at least 2 courses in the first year.

The Doctoral School announces the doctoral courses at the beginning of each semester. Each course (regardless of the number of hours, including reading courses) is worth **5 credits**. The list of regularly announced doctoral courses can be found in Section 3, “Course Lists”.

Upon the doctoral student’s request, participation in **online courses, summer or winter schools, or workshops** can be accepted as a course. The request must be submitted to the Head of the Doctoral School with the **support of the supervisor**.

2.3. Research Credits

The completion of research credits is certified by the supervisor.

Achievements related to research seminars, conferences, and publications can be credited multiple times within a semester. For achievements related to publications, in the case of co-authorship with another doctoral student, the credits may be divided by the Doctoral School Council.

The condition for submitting the doctoral dissertation for review is **at least two published or accepted publications** (including at least one journal article) related to the topic of the doctoral dissertation, published or accepted in a peer-reviewed journal indexed in an international database and published in a world language.

2.4. Teaching Credits

Teaching exercise session for one semester, **2 credits per weekly teaching hour.** A maximum of 8 credits can be earned per semester under this category.

The doctoral student must request the inclusion of teaching credits. The completion is verified and certified by the **teaching coordinator** of the Bolyai Institute.

3. Course Lists

3.1. Algebra

Course Name	Course Code
Group Theory	MN5101EA
Lattice Theory	MN5102EA
Semigroup Theory	MN5103EA
Universal Algebra	MN5104EA
Ordered Sets	MN5105EA
Clone Theory	MN5106EA
Finite Algebras	MN5107EA
Graph Homomorphism Problems	MN5108EA

3.2. Analysis

Course Name	Course Code
Measure and Integration Theory	MN5201EA
Complex Analysis	MN5202EA
Functional Analysis	MN5203EA
Banach Algebras and Operator Theory	MN5204EA
Selected Topics in Functional Analysis	MN5205EA
Approximation Theory	MN5206EA
Potential Theory	MN5207EA
Fourier Series, Fourier Integrals I	MN5208EA
Fourier Series, Fourier Integrals II	MN5209EA

3.3. Dynamical Systems

Course Name	Course Code
Partial Differential Equations	MN5301EA
Dynamical Systems	MN5302EA
Ordinary Differential Equations	MN5303EA
Functional Differential Equations	MN5304EA
Dynamical Models	MN5306EA
Nonlinear Dynamics	MN5307EA

3.4. Discrete Mathematics

Course Name	Course Code
Discrete Mathematics 2	MN5401EA
Extremal Graph Theory	MN5402EA
Mathematical Cryptography	MN5403EA
Combinatorial Computational Models	MN5404EA
Counting Problems	MN5405EA
Algebraic and Random Methods in Combinatorics	MN5406EA
Finite Geometries, Codes, Cryptography	MN5407EA
Selected Topics in Graph Theory	MN5408EA

3.5. Geometry

Course Name	Course Code
Algebraic Topology	MN5501EA
Combinatorics of Convex Polytopes	MN5502EA
Integral Geometry and Geometric Probability	MN5503EA
High-Dimensional Convex Geometry	MN5504EA
Brunn-Minkowski Theory of Convex Bodies	MN5505EA
Discrete and Combinatorial Geometry	MN5506EA
Stochastic Geometry	MN5507EA
Geometry of Vector Systems	MN5508EA
Selected Topics in Geometry	MN5509EA

3.6. Stochastics

Course Name	Course Code
Probability Theory	MN5601EA
Stochastic Processes	MN5602EA
Financial and Risk Processes	MN5603EA
Mathematical Statistics	MN5605EA
Markov Chains	MN5606EA
Branching Processes	MN5607EA
Selected Topics in Stochastics	MN5608EA

3.7. Didactics of Mathematics

Course Name	Course Code
Problem Solving in Mathematics and Mathematics Teaching	MN5701EA
Research Methodology and Applied Statistics	MN5702EA
Chapters from the Cultural History of Mathematics	MN5703EA
Elementary Combinatorics	MN5704EA
Digital Resources in Geometry Education	MN5705EA
Chapters from the Methodology of Teaching Advanced Mathematics in Secondary and Higher Education	MN5706EA

3.8. Applied Mathematics

Course Name	Course Code
Mathematical Modeling in Data Science	MN5801EA
Network Theory and Agent-Based Modeling	MN5802EA
The Mathematics of Machine Learning and Artificial Intelligence	MN5803EA
Mathematical Control Theory	MN5804EA
Scientific Computing	MN5805EA
Numerical Methods for Differential Equations	MN5806EA
Statistical Analysis of Time Series	MN5807EA

4. The Comprehensive Exam

During the doctoral training, at the end of the fourth semester, **as a conclusion of the training and research phase** and as a prerequisite for starting the research and dissertation phase, a

comprehensive exam must be completed, which evaluates the academic and research progress.

The prerequisite for taking the comprehensive exam is earning **at least 90 credits during the training and research phase (first four semesters)** and completing all study credits required by the training plan of the Doctoral School. Exceptions are made for students preparing individually for the doctoral degree, whose student status is established upon successful completion of the comprehensive exam.

The comprehensive exam consists of **two main parts**: in one part, the candidate's **theoretical** knowledge is assessed (theoretical part), and in the other part, the candidate reports on their **scientific progress** (dissertation part).

In the first, theoretical part of the comprehensive exam, the candidate takes an exam in **two subjects, with two topics from one subject and one topic from the other.** The list of subjects and topics is provided in Section 5, "Subjects of the Comprehensive Exam". The theoretical exam may include a written component.

In the second, dissertation part of the comprehensive exam, the candidate gives a **presentation** on their literature review, reports on their research results, presents their research plan for the second phase of the doctoral training, and outlines the schedule for completing the dissertation and publishing the results.

Before the exam, the supervisor evaluates the candidate in writing, addressed to the chair of the examination committee and sent to the secretary of the Doctoral School.

5. Subjects of the Comprehensive Exam

5.1. Universal Algebra and Lattice Theory

Topics

i. Classical Algebraic Structures
ii. Universal Algebra
iii. Clones
iv. Finite Algebra
v. Lattice Theory
vi. Coordinate Systems in Lattice Theory

5.2. Group and Semigroup Theory

Topics

i. Finite Groups and Fields
ii. Group Theory

iii. Semigroup Theory
iv. Regular Semigroups
v. Universal Algebraic Studies of Semigroup Classes

5.3. Functional Analysis

Topics

i. Functional Analysis
ii. Measure and Integration Theory
iii. Topological Vector Spaces
iv. Banach Algebras
v. Operator Theory

5.4. Classical Analysis

Topics

i. Elements of Real Function Theory
ii. Complex Analysis
iii. Fourier Series
iv. Fourier Integrals
v. Orthogonal Series

5.5. Constructive Analysis

Topics

i. Approximation with Trigonometric and Algebraic Polynomials
ii. Function Spaces and Approximation Operators
iii. Orthogonal Polynomials
iv. Potential Theory and Applications

5.6. Differential Equations

Topics

i. Basics of Ordinary Differential Equations
ii. Basics of Partial Differential Equations
iii. Dynamical Systems

iv. Stability Theory
v. Functional Differential Equations
vi. Partial Differential Equations in Function Spaces

5.7. Geometry

Topics

i. Convex Geometry
ii. Discrete and Combinatorial Geometry
iii. Combinatorics of Polytopes
iv. Classical Integral Geometry
v. Stochastic Geometry
vi. Algebraic Topology
vii. Differential Geometry and Topology

5.8. Discrete Mathematics

Topics

i. Graph Theory
ii. Set Systems
iii. Block Systems and Codes
iv. Counting Problems
v. Complexity Theory
vi. Combinatorial Methods in Geometry
vii. Cryptography and Coding Theory

5.9. Stochastics

Topics

i. Basics and Strong Laws of Probability Theory
ii. Limit Theorems
iii. Chapters from Mathematical Statistics
iv. Stochastic Processes with Discrete State Space
v. Stochastic Processes with Continuous State Space

5.10. Didactics of Mathematics

i. Goals of Mathematics Teaching, Learning Theories
ii. Teaching Euclidean Geometry and Combinatorics
iii. Teaching Elements of Algebra and Calculus
iv. Teaching Elements of Probability and Statistics
v. History and Philosophy of Mathematics in Mathematics Education

5.11. Applied Mathematics

i. The Mathematics of Machine Learning and Artificial Intelligence
ii. Network Theory and Agent-Based Modeling
iii. Mathematical Control Theory
iv. Numerical Mathematics
v. Statistical Analysis of Time Series

6. Credit Distribution and Sample Curriculum in Tabular Form

6.1. Credit Table

Weekly Regular Consultation with Supervisor	10 credits
Processing of Scientific Literature	10 credits
Survey of Research Problems	5 credits
Research Project Report	5 credits
Participation in Research Seminar (2 hours per week)	3 credits
Presentation at Research Seminar	3 credits
Presentation at Hungarian Conference	3 credits
Presentation at International (Foreign Language) Conference	5 credits
Technical Report	10 credits
Submission of Publication to Peer-Reviewed Journal in a World Language	15 credits
Final Acceptance of Publication in Peer-Reviewed Journal in a World Language	15 credits
Other Accepted Scientific Publication	10 credits

6.2. Sample Curriculum (Recommended)

Semester	**1**	**2**	**3**	**4**	**5**	**6**	7	8	**Total**
Studies									
Courses (credits)	10	5	5	5					**25**
Teaching (credits)	4	4	4	4	4	4			**24**
Research (can be taken once per semester)									
Processing of Scientific Literature; Technical Report; Weekly Regular Consultation with Supervisor (10 credits)	20	20	20	20					**80**
Survey of Research Problems; Research Project Report (5 credits)					5	10	10		**25**
Research (can be taken multiple times per semester)									
Participation in Research Seminar (2 hours per week); Presentation at Research Seminar; Presentation at Hungarian Conference (3 credits)				3	9	9			**21**
Presentation at International (Foreign Language) Conference (5 credits)						5	5		**10**
Submission of Publication to Peer-Reviewed Journal in a World Language (15 credits)							15	15	**30**
Final Acceptance of Publication in Peer-Reviewed Journal in a World Language (15 credits)								15	**15**
Other Accepted Scientific Publication (10 credits)					10				**10**
Total (credits)	**34**	**29**	**29**	**32**	**28**	**28**	**30**	**30**	**240**

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