

# Topics for MSc Thesis for Applied Mathematics MSc, 2021

## UNIVERSITY OF DEBRECEN, FACULTY OF SCIENCE AND TECHNOLOGY, INSTITUTE OF MATHEMATICS

Nr.	Supervisor	Topic	Prerequisites
1.	Zoltán Boros	<i>Translation equation and iterations</i>	
2.	Borbála Fazekas	<i>Numerical methods for partial differential equations</i>	Knowledge on partial differential equations is needed.
3.	Borbála Fazekas	<i>Numerical methods for solving systems of linear equations</i>	
4.	Figula Ágota	<i>Finite projective planes and small Steiner triple systems</i>	
5.	György Gát	<i>Convergence properties of multidimensional trigonometric Fourier series</i>	
6.	György Gát	<i>Properties of the one and multidimensional Hilbert transform</i>	
7.	Zoltán Muzsnay	<i>Geometry of spacetime</i>	
8.	Ábris Nagy	<i>Geometric tomography</i>	
9.	Gergő Nagy	<i>Representation theorems in functional analysis</i>	TTMME0203
10.	Eszter Novák-Gselmann	<i>Invariant functionals</i>	Reliable foundation from the following fields is needed: Measure and integration, Functional analysis, Topological spaces and Group theory.
11.	Tengely Szabolcs	<i>The Gion shrine problem</i>	SageMath, LaTeX

The topics marked by a \* are taken.

*The application form can be downloaded from the website of the Faculty of Science and Technology. After previous discussion with the supervisor of the chosen topic and having his/her permission for the application, the form (without signatures) has to be submitted by e-mail to Adrienn Kovácsné Kiss (adrienn.kiss@science.unideb.hu) until the 8th of May.*

## Summaries of topics

1. The translation equation  $f(f(x, t), s) = f(x, t + s)$  describes iterative (semi)groups as particular cases. The purpose of the project is the description of the general solution of the equation. Collection of various results and problems concerning the possibility of embedding various classes of functions and the existence of iterative roots is also involved.
2. The aim of this work is to demonstrate numerical methods for partial differential equations, especially to demonstrate the finite element method.
3. The aim of this work is to demonstrate numerical methods for solving systems of linear equations. We are interested in methods which are not contained in the basic numerical analysis courses.
4. The purpose of this topic is to show that among the Steiner triple systems with small cardinality only one is embeddable into a finite Desarguesian projective plane.
5. Investigation of the convergence properties of multidimensional trigonometric Fourier series: Rectangular, triangular and spherical partial sums and means. The main aim is to describe some known summability methods: Cesaro, de la Vallee-Poussin, Picard and Bessel, Riesz and Weierstrass means. An outlook to theta summation.
6. The Hilbert and the maximal Hilbert transforms play a key role in the theory of trigonometric Fourier series. Plan: The description of their properties with the help of Calderon-Zygmund decompositions, the proof that these operators are bounded from the Lebesgue space  $L^p$  to  $L^p$  for any finite number  $p > 1$ . Discussion of the case  $p = 1$ .
7. -
8. Geometric tomography deals with the retrieval of information about a geometric object from data concerning its projections, cross-sections or both. The word geometric refers to that the object is homogeneous and thus we are only interested in the shape of the object. Geometric tomography is a geometric relative of computerized tomography (or CT as most people know it). Hence problems related to geometric tomography can be handled with methods known in tomography, however in geometric tomography it's possible to answer such questions as uniqueness of solutions, and the problem of approximation, especially when the object is convex.
9. Representation theorems in functional analysis are statements describing the general forms of maps having certain properties. The majority of them concern continuous linear functionals on special spaces that are of particular importance in that area, e.g. Hilbert spaces and function spaces. Among those, there are the well-known and fundamental theorems of Frigyes Riesz. Beside material related to the former results, the structure of representations and homomorphisms of abstract operator algebras would also be discussed.
10. Topics intended to be studied can be found in the monograph of Edwin Hewitt and Kenneth A. Ross entitled Abstract harmonic analysis and are the following:
  - The Haar measure and the Haar integral
  - Invariant means defined for all bounded functions
  - Invariant means for mean periodic functions
11. The subject of this work is the famous Gion shrine geometry problem from eighteenth-century Japan. Mathematical tablets (sangaku) were commonplace in temples and shrines throughout Japan, for example in Kyoto's Gion shrine (known today as the Yasaka shrine). There are some known solutions, e.g. the classical Japanese solution and there is one based on the theory of elliptic curves. The latter one has the advantage to conclude that there are no solutions having all rational values. Our goal is to check if we can find solutions in some fixed quadratic/quartic number fields.