Applied mathematics M.Sc. – Thesis topics 2024
University of Debrecen, Institute of Mathematics

DEPARTMENT OF ALGEBRA AND NUMBER THEORY

The Gion shrine problem
- **Name of subject leader:** Dr. Szabolcs Tengely
- **Language:** english
- **Remark:** SageMath and LaTeX
- **Abstract:** 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.

DEPARTMENT OF ANALYSIS

Basics of calculus of variations
- **Name of subject leader:** Dr. Tibor Kiss
- **Language:** -
- **Remark:** -
- **Abstract:** The aim of the thesis is to discuss in detail the basic tools of calculus of variations, with special emphasis on the Euler–Lagrange Equation, and then to apply them to real life examples. In our problems, the functionals we wish to minimize are given as definite integrals of the unknown function.

Continuity concepts for set valued mappings
- **Name of subject leader:** Dr. Zoltán Boros
- **Language:** -
- **Remark:** -
- **Abstract:** We introduce the concepts of lower and upper semicontinuous set valued mappings. We give some necessary as well as some sufficient conditions and investigate some important particular cases. Applications in the theory of fixed points are discussed as well.

Dynamical systems
- **Name of subject leader:** Dr. Borbála Fazekas
- **Language:** -
- **Remark:** -
- **Abstract:** A dynamical system is a structure, where we are given a set of states and a rule that describes the change of the system from one state to another during a given timeperiod. Examples for dynamical systems are the mathematical pendulum or the flow of a fluid in a pipe.

Invariant functionals
- **Name of subject leader:** Dr. Eszter Novák-Gselmann
- **Language:** english
- **Remark:** Reliable foundation from the following fields is needed: Measure and integration, Functional analysis, Topological spaces and Group theory.
- **Abstract:** 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.

Representation theorems in functional analysis
- **Name of subject leader:** Dr. Gergő Nagy
- **Language:** english
- **Remark:** Prerequisities: TTMME0203

- **Abstract:** 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.

DEPARTMENT OF GEOMETRY

Finite geometry and its applications in coding theory and cryptography

- **Name of subject leader:** Dr. Ágota Figula
- **Language:** -
- **Remark:** -
- **Abstract:** Using the book Kiss György-Szőnyi Tamás: Finite Geometries, CRC Press Taylor & Francis Group, 2020, and other relevant sources we discuss some applications of finite geometry, for instance in coding theory and cryptography.

Finite projective planes

- **Name of subject leader:** Dr. Ágota Figula
- **Language:** -
- **Remark:** -
- **Abstract:** We describe some interesting examples of finite projective planes, for instance: free plane of Hall, cyclic planes, planes which do not satisfy the Desarguesian theorem, small planes, planes of order 2, 3, . . .

The geometry of curved spaces

- **Name of subject leader:** Dr. Zoltán Muzsnay
- **Language:** -
- **Remark:** -
- **Abstract:** -

Tomography

- **Name of subject leader:** Dr. Ábris Nagy
- **Language:** english
- **Remark:** -
- **Abstract:** Tomography is a discipline, where images of cross-sections of a body are produced in order to reveal the inner structure of the body. During a CT-scan, x-ray beams penetrate through the human body and the change of intensities of these beams are measured. Then the inner structure is revealed with the help of mathematical computations. However, tomographic examinations can be performed not just for the human body, but structures made of metal, or a piece of rock, or even the Earth's atmosphere. The mathematical problem is to reconstruct an unknown distribution of a physical quantity with the knowledge of the values of line integrals along straight lines. The discrete version of this problem is when we wish to find an unknown finite point set in the plane having only the number of elements contained by a finite set of lines. Discrete tomography deals with the solution of this problem, where methods of combinatorics and graph theory arise naturally. The reconstruction of binary matrices by their line and column sums is a special topic with several possible simple solutions. Several answers exist for this problem with easy and strightforward computations.