Designs and Codes — Summer 2017

Course webpage

`http://discretemath.imp.fu-berlin.de/DMIII-2017/`

Instructors

Martin Aigner
Arnimallee 3, Room 205
aigner@math.fu-berlin.de

Shagnik Das
Arnimallee 3, Room 204
shagnik@mi.fu-berlin.de

Schedule

Lectures: Tuesdays, 12:30-14:00, in Arnimallee 6, SR 031.
Exercises: Wednesdays, 12:30-14:00, in Takustraße 9, SR 005.

Topics of the course

"Code" has become a household word, and probably everybody knows (vaguely) that good codes determine much of modern life. Mathematically, a good code is a very regular arrangement of codewords, or what we call a design. In this course we treat the basics of designs and codes, discuss several important examples, and focus on the algebraic methods for constructing good designs with given parameters or proving their nonexistence.

Course contents:

- Basic concepts of designs, projective planes and Hadamard matrices, and nonexistence results
- Latin squares and Euler's conjecture
- Basics of coding theory, linear codes and perfect codes

Literature

Recommended text:

- J. H. van Lint and R. M. Wilson, *A Course in Combinatorics*.

Prerequisites

This course is a third course in the Discrete Maths module. Successful completion of Discrete Maths I is required, and completion of a Discrete Maths II course is highly recommended.

Firm knowledge of linear algebra and matrices is required, and a good background in finite fields would be very useful.

Presentations

On odd weeks, when the homework assignments are due, solutions to the exercises will be discussed in the exercise classes on Wednesdays. On even weeks, when there is no homework due, the Wednesday classes will be used for additional lectures, covering related topics in greater depth.

Ideally, we would prefer that you, the students, make these presentations. The topics will be posted to the course website in advance, and you are welcome to volunteer to deliver the lecture. When you volunteer, you will be provided with some notes and/or references, and should then meet with us at least a few days in advance of the class to discuss your plans for how you will present the material. We will give you some feedback and suggestions and, if you are adequately prepared, you will then lead the class on Wednesday.

When you present in one of these classes, you will earn credit for the following week's homework assignment, which you will then not need to hand in. You may also share the presentation duties with your homework partner, working together to learn the material and then each giving half of the lecture.

Should there not be any students volunteers for one of these classes, then the topics will be presented as normal by the instructors. Do note that this material is considered part of the course (and thus, in particular, is examinable), and so attendance is strongly recommended.

Requirements for "active participation at the exercises"

The "aktive Teilnahme" credit for this course is based on three components: collecting points on the homework, authoring solutions to the homework problems, and presenting solutions during the exercise classes. We now explain what is required in greater detail.

During the semester, there will be six exercise sheets, one every two weeks. Each sheet will have five or six exercises, and you should **submit solutions for three exercises** that you would like corrected. If you want to excel in your craft, you are strongly encouraged to try to solve all exercises, not least because any of them may appear in the final exam. All solutions you submit will be looked at, but you must clearly indicate which three should be graded for credit.

Your written submissions are due at the beginning of the exercise classes on odd weeks. **Late solutions will not be accepted.** Your submission will be graded and returned to you in the following exercise class. For the signature on the exercises ("aktive Teilnehme") you must earn at least **60% of the total score** (each exercise will be worth 10 points).

It is very beneficial to think about and discuss mathematics in small groups. You are encouraged to solve the exercises in study groups and **submit your solutions in pairs**. Please remember to clearly write the names of both members of the pair on your submission.

We would also like to encourage you to please feel free to approach us to discuss your thoughts on particular exercises and ask for hints when stuck. Nevertheless, we discourage you from searching for solutions on the Internet. Most likely you *can* find one to most exercises, but copied solutions will never give you the deep understanding necessary to succeed on the final, so you unfortunately cannot spare the struggle on your

own or with your study group while trying to solve exercises. Actually, *why* would you want to: that's exactly the most creative and enjoyable part of the course!

It is also crucial to practice writing up proofs and solutions independently. Hence every student is required to **write up solutions to at least six graded problems** (out of the eighteen total for her or his pair). In order to properly get credit for this, please **clearly state the name of the author at the beginning of each solution to be graded**.

Finally, each student must **present a correct solution in the exercise classes at least once** in the semester. We recommend you take care of this requirement as early as possible — time is limited during these exercise classes, and it will not be possible for everyone to present in the last couple of weeks.

In conclusion, to earn the "aktive Teilnahme", you need to meet each of the following criteria:

- earn at least 60% of the point value of $3 \times 6 = 18$ homework problems,
- individually author at least six solutions, and
- present at least one correct solution in the exercise classes.

Final exam

The grade for the course is based solely on the final oral exam. The first round of exams will take place in the middle of July, around the end of the lecture period, with a second round around in either September or October, towards the end of the term break — specific times will be fixed later. The final is a closed-book/closed-notes exam; you must learn everything that was presented and be familiar with how to apply the methods and results. In order to succeed, it is absolutely necessary to actively follow the lectures throughout the semester, revise the new material, and try to solve the exercises. There will be two different types of tasks on the final:

- Lexical knowledge: definitions, statements and proofs of theorems
- Problem solving: applying the encountered theorems and methods to solve exercises (some of these may be from the homework, some may be new)