McGill University

Department of Mathematics and Statistics

MATH 550 Combinatorics. Winter '16

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Office: Burnside 1116 Office Phone: (514) 398-3819
Office Hours: Monday 12:30-14:30 and by appointment

Lecture Times: MW 14:35–15:55 Location: Burnside 1205

Textbooks

There is no required text. Suggested textbooks:

[BB] Bela Bollobas. Combinatorics. Cambridge Univ. Pr. 1986.

[JM] Jiri Matousek. Lectures in Discrete Geometry. Springer. (Grad. Texts in Math.) 2002.

[TV] Terence Tao, Van H. Vu. Additive Combinatorics. Cambridge Univ. Pr. (Cambridge Studies in Adv. Math.) 2009.

Course Description

The course is intended primarily for honours and graduate students in mathematics. The course focuses on extremal combinatorics and its applications to discrete geometry and additive number theory. Highlights of the course include:

- Sperner's, Erdos-Ko-Rado and Kruskal-Katona theorems in extremal set theory;
- Littlewood-Offord problem and its generalizations;
- Ramsey theory, including Van der Waerden's theorem;
- Turan-type problems in graph and hypergraph theory;
- Szemer´edi-Trotter theorem and its applications to additive combinatorics;
- Algebraic methods: Combinatorial Nullstellensatz

Evaluation

Homework assignments	30%
Midterm (in class)	15%
Final (take home)	35%
Presenting a paper (or making a progress on an open problem)	20%

Tentative list of topics

1. Set systems: Sperner systems, Erdos-Ko-Rado theorem.
   - [BB] 3, 7
2. Solution of the Littlewood-Offord problem. Overview of the results related inverse Littlewood-Offord.
   - [BB] 4
   - [TV] 7
3. Shadows of set systems. Kruskal-Katona theorem.
   - [BB] 5
4. Turan type problems. Turan's theorem. Excluding a Fano plane.
   - M. Aigner, G. Ziegler. Proofs from The Book.
   - P. Keevash, B. Sudakov. The exact Turan number of the Fano plane.
5. Ramsey theory. Van der Waerden's theorem. Hales-Jewett theorem.
   - R. Graham, B. Rothschild, J. Spencer. Ramsey theory.
6. Planar graphs. Crossing numbers. Hanani-Tutte theorem. The crossing lemma.
   - [JM] 4
   - M. Pelsmajer, M. Schaefer, D. Stefankovic. Removing even crossings.
   - W. Tutte. Towards a theory of crossing numbers.
7. Point-line incidencies. The Szemeredi-Trotter theorem. Sum-product estimates.
   - [JM] 4
   - [TV] 8
8. Helly's theorem. Tverberg's theorem. Colorful Caratheodory theorem
   - [JM] 8
9. Algebraic methods in combinatorics. Combinatorial Nulstellensatz.
   - [TV] 9
   - N. Alon. Combinatorial Nullstellensatz.
10. Shannon capacity. Lovasz Theta function. Semidefinite programming.
    - L. Lovasz. Shannon capacity of a graph.
    - J. Kleinberg, M. Goemans. Lov´asz theta function and a semidefinite programming re- laxation of the vertex cover.

Assignment Details

There will be 3 homework assignments, each worth 10% of your total grade. You are allowed and encouraged to discuss the homework problems with other students.

Academic integrity

McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offenses under the Code of Student Conduct and Disciplinary Procedures (see http://www.mcgill.ca/integrity for more information). Most importantly, work submitted for this course must represent your own efforts. Copying assignments or tests from any source, completely or partially, allowing others to copy your work, will not be tolerated.

Miscellaneous

- In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded.
- In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.