TOPICS IN COMBINATORICS – ALGEBRAIC METHODS IN COMBINATORICS

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Spring Semester 2013

Course number: 0366-4933.
Course webpage: www.math.tau.ac.il/~krivelev/teaching/AlgebrMethods/AMC.html
When and where: Wednesdays 15-18, Shenkar-Physics 204.
Prospective audience: the course is intended for graduate and advanced undergraduate students in Mathematics and Computer Science.
Informal prerequisites: working knowledge of graph theory notions; knowledge of basic concepts in linear algebra.
Grading: Home assignments will be given roughly every other week, and their solutions will be graded.

Syllabus (tentative)

1. Introduction to linear algebraic methods in Combinatorics. Illustrative examples.

2. Set systems with restricted intersections. Frankl-Wilson theorem and its modular version. Consequences: constructive Ramsey graphs, chromatic number of R^n, counterexample to Borsuk's conjecture.

3. Combinatorial Nullstellensatz. Chevalley-Warning theorem. Applications to additive number theory, combinatorics, geometry.

4. Set pair systems, exterior products, Bollobás theorem.

5. Shannon capacity and Lovász θ-function.

6. Graph eigenvalues – definition, illustrative examples.

7. Properties of graph eigenvalues, applications of graph eigenvalues.

8. Eigenvalues and expansion. Pseudo-random graphs. (n, d, λ)-graphs and their properties.

Bibliography

1. L. Babai and P. Frankl, *Linear Algebra Methods in Combinatorics*, Department of Computer Science, University of Chicago, preliminary version, 1992.

2. Vol. II of *Handbook of Combinatorics*, esp. Ch. 31 "Tools from Linear Algebra" by C. G. Godsil, and Ch. 32 "Tools from Higher Algebra" by N. Alon, North-Holland, 1995.

3. S. Jukna, *Extremal Combinatorics*, 2nd Ed, Springer, 2011.

4. J. Matoušek, *Thirty three miniatures, Mathematical and Algorithmic Applications of Linear Algebra*, American Math. Society, 2010.

5. A. E. Brouwer and W. H. Haemers, *Spectra of Graphs*, Springer, 2012.