
1. Combinatorics

(a) **Enumeration**

Binomial and multinomial coefficients, Stirling's formula, recursions and generating functions, inclusion-exclusion principle

(b) **Posets and Lattices**

Dilworth's theorem, LYM inequality, Sperner's theorem, Mobius inversion formula, Birkhoff's representation theorem, Weisner's theorem, geometric lattices

(c) **Hypergraphs**

Erdos-Ko-Rado theorem, Kruskal-Katona theorem, Fisher's inequality, Ray-Chaudhuri Wilson theorem, Frankl-Wilson theorem, Baranyai's theorem

(d) **Ramsey Theory**

Ramsey's theorem, Van der Waerden theorem

(e) **Discrepancy Theory**

Beck-Fiala theorem

2. Graph Theory

(a) **Matching Theory**

Konig's theorem, Hall's marriage theorem, Tutte's 1-factor theorem, Petersen's theorem, Birkhoff-von Neumann theorem

(b) **Connectivity**

Menger's theorem

(c) **Planarity**

Euler's formula, Kuratowski's theorem, Wagner's theorem

(d) **Coloring**

Five color theorem, Brooks' theorem, Konig's theorem, Vizing's theorem, perfect graph, list coloring, Galvin's theorem

(e) **Flows**

Max-flow min-cut theorem

(f) **Extremal Graph Theory**

Turan's theorem, regularity lemma, counting lemma, Erdos-Stone theorem

3. Probabilistic Method

(a) **Basics**

Linearity of expectation, Markov's inequality, Chernoff bound

(b) **Alterations**

Lower bound for the diagonal Ramsey numbers, graph with high girth and high chromatic number

(c) **The Second Moment**

Chebyshev's inequality, threshold functions

(d) **The Local Lemma**

Statement of general case, symmetric case, property B of a hypergraph, lower bounds for diagonal Ramsey numbers

(e) **Correlation Inequalities**

Ahlsvede-Daykin, FKG inequality, Harris' inequality

(f) **Martingales**

Azuma's inequality, vertex and edge exposures

4. Additive Combinatorics

(a) **Sumset Inequalities**

Real case, exact inverse sumset theorem, Cauchy-Davenport theorem, Ruzsa triangle inequality, covering lemmas

(b) **Additive Energy**

Bounds for additive energy, Balog-Szemerédi-Gowers theorem

(c) **Density of Sumsets of Integers**

Schnirelmann density, Mann's theorem

(d) **The Sum Product Theorem**

The sum product theorem, real case, Erdős-Szemerédi sum-product conjecture

(e) **Fourier Methods**

Parseval's identity, additive energy in Fourier coefficients, Gauss sums, BLR linearity test, formula for the number of 3-arithmetic progressions

(f) **Applications of Szemerédi regularity lemma**

Triangle removal lemma, Roth's theorem

(g) **Polynomial methods**

Combinatorial Nullstellensatz, proof of Cauchy-Davenport theorem, Erdős Heilbronn conjecture

(h) **Waring problem**

(i) **Hindman's theorem**