Advanced Combinatorics – 3450:636-001

INSTRUCTOR: Dr. Stefan Forcey EMAIL: sf34@uakron.edu
OFFICE: CAS 275 PHONE: 972-6779
OFFICE HOURS: MWF 1:15-2:15
Advanced combinatorics will both extend the material covered in an introductory course and highlight some of the current developments in the field.
Website http://www.math.uakron.edu/~sf34/class_home/advcomb/advcombs18.htm

Texts: Download or bookmark these soon, in case they aren't available online all semester!
[Korte] B. Korte, J. Vygen: Combinatorial Optimization Theory and Algorithms Fourth Edition
http://ebooks.ohiolink.edu/xtf-ebc/view?docId=tei/sv/9783540718444/9783540718444.xml;chunk.id=ch1;toc.depth=1;toc.id=;brand=default
[Stanley1] R. Stanley: Enumerative Combinatorics
http://math.mit.edu/~rstan/ec/ec1.pdf
[Bergeron] N. Bergeron et.al.: Introduction to Species
http://bergeron.math.uqam.ca/wp-content/uploads/2013/11/book.pdf
[Stanley2] R. Stanley: The Catalan addendum:
http://math.mit.edu/~rstan/ec/catadd.pdf
[Wilf] H. Wilf: generatingfunctionology
http://www.math.upenn.edu/%7Ewilf/DownldGF.html
[Ziegler] Ziegler et.al. : BASIC PROPERTIES OF CONVEX POLYTOPES
http://fma2.math.uni-magdeburg.de/~henk/preprints/henk%20richter-gebert%20ziegler&basic%20properties%20of%20convex%20polytopes.pdf
[Thomas] R. Thomas: Lectures in Geometric Combinatorics
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.6495&rep=rep1&type=pdf
(This last one was still online last I checked, also inexpensive at www.ams.org)

Supplementary material:
[Waner] Stefan Waner: Linear Programming http://www.zweigmedia.com/RealWorld/Summary4.html
Simplex method: http://www.zweigmedia.com/RealWorld/tutorialsf4/framesSimplex.html
Online calc: http://www.zweigmedia.com/RealWorld/simplex.html
[Cook] William Cook et.al. Traveling Salesman Problem http://www.math.uwaterloo.ca/tsp/index.html
Subtours http://www.math.uwaterloo.ca/tsp/methods/opt/subtour.htm

Phylogenetic trees
https://plus.maths.org/content/reconstructing-tree-life
Cutting planes
http://www.unc.edu/~pataki/papers/teachtsp.pdf
Order theory glossary
http://en.wikipedia.org/wiki/Order_theory_glossary#P
Monoidal Functors, Species and Hopf Algebras by M. Aguiar and S. Mahajan
http://www.math.tamu.edu/~maguiar/a.pdf
A Survey of the Riordan Group by Louis Shapiro
http://www.combinatorics.cn/activities/Riordan%20Group.pdf
Wikipedia: http://en.wikipedia.org/wiki/Tutte_polynomial
http://en.wikipedia.org/wiki/Graph_theory
http://en.wikipedia.org/wiki/Minkowski_addition
Blogs: John Baez:This week's finds. http://math.ucr.edu/home/baez/week202.html
http://math.ucr.edu/home/baez/week144.html
Gil Kalai: Combinatorics and more. http://gilkalai.wordpress.com/

GRADING POLICY: The following percentages will be used in grading:

50% Homework/Quiz	90% guarantees an A
30% Presentations (2 at 15% each.)	80% guarantees a B
	70% guarantees a C
20% Final Exam	60% guarantees a D

Homework and take-home quiz problems should be attempted individually at first. After that, research and collaboration are permitted as long as you actually cite any published sources and credit any persons who helped you.

Presentations: Everyone presents twice from these options: 1) a classic LP or IP problem and its polytope; 2) a well-known polytope and its combinatorics; 3) a greedy algorithm or other algorithm.

Course Outline with dates:

- Jan. 16: Day one.
- Structures on sets.
- Jan. 31: Last day to drop.
- Polytopes.
- **presentation 1.**
- March 5: Last day to w/draw.
- Species.
- **presentation 2.**
- March 26-30: Spring break.
- May 3: Last day.
- Final Exam 5/10/2018, Thursday 2:30PM - 4:30PM Leigh Hall 408

Tentative Topic outline:

0. Linear programming intro [Cook] [Korte chap. 21]

I. Some structures: Posets and topologies. [Stanley1, chapter 3 and following]
   A. Orders, finite topology
   B. Lattices
   C. Examples: Tamari, Weak lattice of permutations, Boolean lattice

II. Geometric Combinatorics [Ziegler]
   A. Polytopes: convex hulls, half-spaces, products, pyramids, polars
   B. Cuts in a graph, cut polytope, min cut max flow,
   C. matchings and permutation polytopes: birkhoff
   D. Linear ordering, polytope, simplex method on edges. [Waner]
   E. linear programming example presentations
   F. simplex algorithm
   G. branch and bound
   H. Hasse diagrams
   I. Skeletons
   J. Associahedra
   K. Minkowski sums [Thomas]
   L. Euler's formula and Platonic solids

III. Species [Bergeron][Stanley2]
   A. Definitions and examples.
   B. Categories and functors.
   C. Species and generating functions
   D. Examples
   E. Operations on species (+, . , o)
   F. Transforms, Riordan group.
   G. Operads

----------optional topics----------

IV. Algebraic Combinatorics
   A. Algebras, Graphs and Trees: planar trees, grafting, splitting
   B. Coalgebras
   C. Bialgebras
   D. Polytopes again.
   E. Moebius inversion, Algebras.

V. Tutte Polynomial
   A. Recursive calculation
   B. Interpretation
   C. Jones polynomial

VI. Computer Science, Chemistry and Biology
   A. P vs NP
   B. Benzenoids and polyhexes
   C. Phylogenetic trees and DNA .
   D. Network theory, Petri nets, Shannon capacity
   E. Combinatorial games.