**Advanced Combinatorics – 3450:636-001**

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**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/advcombs16.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/files/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](http://www.ams.org))

[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>

**Supplementary material:**

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

30% Presentations (2 at 15% each.)

20% Final Exam/Project

90% guarantees an A

80% guarantees a B

70% guarantees a C

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. 19: Day one.

• Structures on sets.

• Feb. 2: Last day to drop.

• Polytopes.

• **presentation 1.**

• March 2: Last day to w/draw.

• Species.

• **presentation 2.**

• March 21-25: Spring break.

• May 6: Last day.

• Final Exam TBA

Tentative Topic outline:

0. Linear programming intro [Cook]

1. Some structures: Posets and topologies. [Stanley1, chapter 3 and following]
2. Orders, finite topology
3. Lattices
4. Examples: Tamari, Weak lattice of permutations, Boolean lattice
5. Geometric Combinatorics [Ziegler]
6. Polytopes: convex hulls, half-spaces, products, pyramids, polars
7. Cuts in a graph, cut polytope, min cut max flow,
8. matchings and permutation polytopes: birkhoff
9. Linear ordering, polytope, simplex method on edges. [Waner]
10. linear programming example presentations
11. simplex algorithm
12. branch and bound
13. Hasse diagrams
14. Skeletons
15. Associahedra
16. Minkowski sums [Thomas]
17. Euler’s formula and Platonic solids
18. Species [Bergeron][Stanley2]
19. Definitions and examples.
20. Categories and functors.
21. Species and generating functions
22. Examples
23. Operations on species (+, . , o)
24. Transforms, Riordan group.
25. Operads

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

1. Algebraic Combinatorics

A. Algebras, Graphs and Trees: planar trees, grafting, splitting

B. Coalgebras

C. Bialgebras

1. Polytopes again.
2. Moebius inversion, Algebras.
3. Tutte Polynomial
4. Recursive calculation
5. Interpretation
6. Jones polynomial
7. Computer Science, Chemistry and Biology
8. P vs NP
9. Benzenoids and polyhexes
10. Phylogenetic trees and DNA .
11. Network theory, Petri nets, Shannon capacity
12. Combinatorial games.