University of Manitoba
Faculty of Science
Department of Mathematics

1 General Course Information

Course Title & Number	MATH 8210-Topics in Combinatorics 1 Extremal combinatorics
Number of Credit Hours	3
Prerequisites	Permission of instructor.
Term	Winter 2022
Calendar Description	Topics will be chosen from the areas of algebraic combinatorics, coding theory, design theory, enumerative combinatorics, graph theory,
Course website	UM Learn
Class Times	TBD Classes held as video conference meetings using Zoom (see website)

Instructor contact information:

Instructor's Name	Dr. Karen Gunderson
Preferred Form of Address	Dr. Gunderson
Office Location	467 Machray Hall
Office Hours or Availability	Zoom meetings – schedule TBD
Office Phone Number	204-474-7486
Email	Karen.Gunderson@umanitoba.ca

Instructor's Name	Dr. Karen Meagher (University of Regina)
Office Hours or Availability	Zoom meetings – schedule TBD
Email	meagherk@uregina.ca

Instructor's Name	Dr. Venkata Raghu Tej Pantangi (University of Lethbridge)
Office Hours or Availability	Zoom meetings – schedule TBD
Email	

Textbooks:

- (**Main text**) S. Jukna, *Extremal Combinatorics*, With applications in computer science, Second edition., Texts in Theoretical Computer Science, An EATCS Series, Springer, Heidelberg, 2011.
  https://search.lib.umanitoba.ca/permalink/01UMB_INST/1p55dqn/alma99140264500001651
- (**Selected chapters**) B. Bollobás, *Modern graph theory*, Graduate Texts in Mathematics, **184**. Springer-Verlag, New York, 1998.
  https://search.lib.umanitoba.ca/permalink/01UMB_INST/8b5fi9/alma99149489486801651

- A. E. Brouwer, C. A. van Eijl, On the p-rank of the adjacency matrices of strongly regular graphs, *J. Algebraic Combin.* **1** (1992), no. 4, 329–346.
- C. D. Godsil, G. F. Royle, Chromatic number and the 2-rank of a graph, *J. Combin. Theory Ser. B* **81** (2001), no. 1, 142–149.
- (**Selected chapters**) A. Prasad, *Representation theory: A combinatorial viewpoint*, Cambridge Studies in Advanced Mathematics, **147**, Cambridge University Press, Delhi, 2015.
- R. P. Stanley, Smith normal form in combinatorics, *J. Combin. Theory Ser. A* **144** (2016), 476–495.
- For optional references, links to electronic copies available through the library will be listed on UM Learn.

2 Course Topics

The following table will provide a rough estimate of the pacing of the course. This schedule is subject to change at the discretion of the instructor and/or based on the learning needs of the students but such changes are subject to Section 2.8 of the ROASS Procedure). Topics in some sections will also be supplemented with detailed lecture notes. Topics in brackets will be covered if time permits.

We will be exploring topics in extremal combinatorics from problems for set systems to graph theory and hypergraphs. These include:

Lectures by Dr Meagher (approx 4 weeks):

- Chains and antichains: Sperner's Theorem; Kruskal-Katona Theorem; Bollobás's intersecting sets theorem.
- Extremal combinatorics and the linear algebraic method: Maximum intersecting sets; cross-intersecting sets; Stability arguments; Sunflowers; Erdős-Ko-Rado; Isoperimetric problems; Cheeger constants.

Lectures by Dr Gunderson (approx 4 weeks):

- Extremal numbers for graphs: Mantel's Theorem, Turán's Theorem, Kövári-Sós-Turán Theorem, Zarankiewicz numbers, Erdős-Stone-Simonovits Theorem.
- Extremal numbers for matchings.
- Turán numbers for small hypergraphs.

Lectures by Dr Pantangi (approx 4 weeks):

- Extremal problems for graph eigenvalues: Diameters and eigenvalues; Eigenvalues and distances between subsets/among many subsets; eigenvalues of symmetric graphs; Distance transitive graphs; eigenvalues and group representation theory.
- Combinatorial matrix theory: Symmetric polynomials and their connections to characters of symmetric groups; association schemes and distance regular graphs; and smith normal forms of combinatorial matrices.

If time permits, the last week of lectures will be used for student presentations.

3 Course Evaluation

Students in this course will be evaluated according to the following table.

Details on each type of assessment can be found in Section 4.

Assessment	**Value of Final Grade**
Assignments	60%
Project	30%
Presentation	10%

There is no final exam in this class.

Students will be given a letter grade using the following table as guaranteed minimums for achieving a particular grade.

Grade	A+	A	B+	B	C+	C	D
Percentage	90	80	72.5	65	57.5	50	40

4 Assessment Descriptions

4.1 Assignments

There will be 6 problem set assignments administered via Crowdmark. These problem sets will be made available approximately one week before the deadline. The deadlines are listed in Section **??**. Please see Section **??** for resources on using Crowdmark. Please also read the page on UM Learn on "Submitting handwritten work".

For the questions on these assignments, full explanations and proofs are required for your solutions. Even for computational problems, a correct solution without proper explanation will receive few points.

Late assignments will be assessed a 10% penalty per hour (or portion thereof). Your final assignment grade will be calculated with the lowest problem set score dropped.

Your work on these assignments must be your own and follow the guidelines for academic integrity in Section **??**. While you may discuss the problems with other students, your work must be your own and cite any discussions with other students for each question. If you have questions, please ask the instructor.

4.2 Project

The project will be an exposition on your chosen topic aimed at the level of a beginning graduate student reader. The project should contain at least one proof of a main theorem on the topic and be fully referenced. The project will be graded on organization, quality of exposition, mathematical accuracy, and use of references. Projects are expected to be around 10–15 pages.

More detailed requirements and a list of possible topics will be made available.

4.3 Presentation

The presentation will be a 15-20 minute talk on the subject of your project, recorded and submitted to a folder on UM Learn.

The intended audience for the presentation is fellow student in the course. Your talk should give some motivation for the topic, explanation of the main result, and at least one proof or proof-sketch. You need not cover all of the material in your project, but can focus on a central part. There should be a visual component to the presentation that can either be pre-prepared slides or else writing/drawing on a blackboard/whiteboard presented together with the verbal descriptions and explanations.

Further details will be given on the course website, including some ideas for how to record your talk.