

# Math 4813, Groups and Representations

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Course Information

Summer 2019

**Professor:** Dr. Lisa Mantini, 410 Math Sciences

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- ▷ Office hours: morning times will be available for discussion of course materials, by appointment.

**Course Times:** This is an online course with no scheduled meeting times.

**Course Objectives:** The aim of this course is to introduce you to my favorite topic in abstract algebra, the theory of groups and their *representations*, or actions as symmetry groups of objects like geometric figures, molecules, or data sets. Our objective is to know and be able to use basic topics in group theory (subgroups, cosets, conjugacy classes, quotient groups, etc.), then group actions both in the abstract and as linear transformations inside a vector space. Then we will study representation theory and character theory. We will finish with what I like to call the *numerology* of finite groups, some amazing facts seen in simple numerical relationships that have profound implications for the underlying groups. Our approach will be to blend theorems and proofs with calculation of enough examples to help the core ideas of the course make sense. We will also be both pure and applied mathematicians this term – I hope to end with an application of group theory to chemistry, computing the modes of vibration of a molecule using the character table of its symmetry group. Pretty cool stuff.

**Prerequisites:** The prerequisites are linear algebra (Math 3013 with grade of “C” or better) and an introductory experience in mathematical proof and basic abstract algebra (Math 3613 with grade of “C” or better), or consent of the instructor. Some knowledge of differential equations may be used towards the end – folks who have not studied Math 2233 may need a little tutorial at the time. You’ll find that I may review specific facts when needed, or else feel free to ask for a reminder.

**Texts:** There are three phases of the course, during which we use material from different sources. I will review facts from linear algebra or other subjects as needed.

Part I: Introduction to Groups: we will use typed notes from a textbook I am writing.

Part II: Representation Theory: We will use primarily Chapters 2–4 from the book *Representation Theory of Finite Groups: An Introductory Approach* by Benjamin Steinberg. Notice that this book is published by Springer Verlag, who has made their textbooks available in electronic format through the OSU Library’s website. Feel free to access and use the ebook. It is a bit terse – I’ll try to add more detail in class notes.

Part III: Applications. We will briefly study applications of representation theory in chemistry and physics through the theory of molecular vibration at the end of the semester. I’ll provide material based on Chapter 32 of *Representations and*

*Characters of Groups*, second edition, by Gordon James and Martin Liebeck. I will post scans of the relevant chapters on Canvas.

**Course Requirements:** Students enrolled in this course will complete the following:

ITEM	DUE DATE	POINTS	WEIGHT
Exam 1	Wednesday 3 July	125 pts	25%
Exam 2	Monday 29 July	125 pts	25%
Assignments	various	160 pts	32%
Final Project	26 July	90 pts	18%
TOTAL		500 pts	100%

**Grading:** The points assigned during the semester add up to a total of 500 points for the course. Preliminary cutoffs for the final course grade are as follows:

- ▷ 450 points (90%) guarantees an A in the course;
- ▷ 400 points (80%) guarantees a B;
- ▷ 350 points (70%) guarantees a C;
- ▷ 300 points (60%) guarantees a D.

**Assignments:** There are approximately 8 homework assignments, worth 20 points each. Written work should be scanned into a single pdf file and uploaded into the Assignment box. Dropbox submissions should be prepared on white or very light colored paper in dark ink and scanned into a single pdf file. No jpg's will be read. You might find a quality scanning app for your phone such as Turboscan (the one I use) or tinyscanner or others to be extremely useful. Title the electronic file with **your last name** and the **assignment number**. In order to receive full credit your work must be clear and legible, you must show all work, and explanations must be written out in correct English sentences. Solutions will be made available after assignments are completed.

**Exams:** There are two exams in this class which I plan on as take-home exams. Due dates are tentatively Wednesday, July 3 and Monday, July 29. Collaboration with others is not permitted on a take-home exam.

**Final Project:** The final written project will be your opportunity to investigate in depth something related to a topic we have covered in this course. You will prepare a written paper on your topic (approximately 5–7 pages in length, typed). Suggested topics will be listed on another handout but include exploration of course topics in more detail or applications to other areas of student interest. The project topic will also be presented to the instructor either in person or via video chat. Due date for the project and presentation is Friday, July 26.

**Class Video:** Our class is presented on video recordings made during the Spring 2019 semester. These were recorded in a live class.

**Drop Policy and Special Dates:** Please see the syllabus attachment for information on drop dates and other important deadlines this semester.

**Academic Dishonesty:** Oklahoma State University is committed to the maintenance of the highest standards of integrity and ethical conduct of its members. This level of ethical behavior and integrity will be maintained in this course. Participating in a behavior that violates academic integrity (e.g., unauthorized collaboration, plagiarism, cheating on examinations, helping another person cheat, and so on) will result in your being sanctioned. Violations may subject you to disciplinary action including the following: receiving a failing grade on an assignment, examination or course, receiving a notation of a violation of academic integrity on your transcript (F!), and being suspended from the University. Carefully read the OSU policy at [academicintegrity.okstate.edu](http://academicintegrity.okstate.edu).

**Homework assignments:** The first few homework assignments are as follows:

ASN	DUE	SECS	PROBLEMS ASSIGNED
1	6/17	1.1	2, 3, 5, 6, 7, 8
		1.2	1, 2, 3
2	6/20	1.2	11, 12, 13, 15, 17, 18, 21, 23
3	6/24	1.3	3, 5, 6, 8, 11, 13, 15, 17
4	6/27	1.4	3, 5a, 10, 14, 15, 16
		1.5	4, 5
5	7/1	1.5	7, 10, 12, 17, 23
		1.6	1, 2, 8, 9
	7/3	Chapter 1	Midterm Exam Due