# MATH 113 Introduction to Abstract Algebra: Syllabus

| | |
|---|---|
| **Instructor:** | Gabriel Dorfsman-Hopkins (gabrieldh@berkeley.edu) |
| **Homework Grader:** | TBA |
| **GSI:** | Foster Tom (ftom@berkeley.edu) |
| **Lecture:** | T,Th 9:30-11:00 AM in Evans 009 |
| **Office Hours:** | Wednesday 9:30-11:00 and Thursday 11:00-12:30 or by appointment. While UC Berkeley is operating remotely office hours will be on Zoom. Once we return to in person instruction they will be held in Evans 895 but will also still be available on Zoom. |
| **GSI Office Hours:** | MTThF 10:00-12:00 on Zoom until further notice. |
| **Text:** | Abstract Algebra, 3rd Edition, by Dummit and Foote [DF] |
| **Secondary Text:** | Paulin's Introduction to Abstract Algebra [P]: https://math.berkeley.edu/~apaulin/AbstractAlgebra.pdf |
| **Course Website:** | http://www.gabrieldorfsmanhopkins.edu/m113sp22/index.html Grades will be posted on bcourses.berkeley.edu. Homework will be collected and graded at gradescope.com. |

## Objectives

You are likely familiar with algebra as being a (perhaps tedious) exercise in solving equations. The structures of addition and multiplication, and the way they intertwine, allow us explicitly to extract information (solve) from relationships (equations).

Abstract algebra is the rigorous study binary operations, that is, functions which take two inputs and one output. You are already familiar with some binary operations (addition and multiplication of integers, for example), but it turns out there are many many more (addition and multiplication of matrices, composition of functions, mixing colors, applying symmetries, permutations and card shuffles, the list goes on). In studying the abstract properties of binary operations and their interactions, we will discover that they all share many very strong underlying structural properties, which allows us to extract information for given relationships (i.e., solve equations), in many different contexts. This leads to applications in cryptography, geometry, logic and even philosophy which we may glance at if time allows.

Along the way we will gain experience in proof writing and mathematical exposition and communication, and get first hand exposure to the abstract axiomatic approach pervasive within all branches of theoretical mathematics.

## Structure

Due to the surge in the COVID-19 pandemic, at least the first two weeks of the course the course will be entirely remote and asynchronous. While we are remote I will post 2 recorded lectures a week, corresponding to our scheduled Tuesday, Thursday lectures, but they will be available to watch at your convenience. I will record them on Zoom and post a link on the course website.

Even once we return in person, I would like to maintain a safe an flexible classroom, equitable for those who are sick or have loved ones to take care of. To facilitate this I will be recording all in

person lectures on my GoPro, and posting those to bCourses. **If you aren't feeling well, please stay home**. There will be no penalty, no assumptions made, and no questions asked.

That being said, mathematics is not a spectator sport, and watching someone do abstract algebra is much like reading the New York Times backwards. All the information may be there, but it will take some unscrambling to make sense of it. For this reason I will have exercises embedded in the lectures. While remote I will suggest you pause the video and work out some of the details, and while in person we will take a moment to wrestle out some details in groups. There will also be many written exercises collected as homework assignments, or takehome exams.

## Discord

I will be curating a channel on discord, and will send out invitations over email. There you will be able to ask questions about homework and lectures, as well as have informal meetings on an audio/video channel. I will monitor the channel and will try to answer questions promptly, but you should feel free to answer questions posted there as well. I hope this is a space for group study and discussion, and to serve as a sort of *open office door*.

## Homework

There will be homework collected almost every week **on Fridays at Noon**. They will be assigned the week before they are due. These assignments will be proofs, as well as computations and explorations of examples. It is preferable that they are typed up using LaTeX, or a similar mathematical typesetting language, but handwritten is ok as well. Just make sure to submit *high quality* scans. **Grainy, blurry, and otherwise illegible scans of homework will not be graded**. Feel free to work in groups, but each student must write up their results separately. **Your lowest homework score will be dropped**.

## Take Home Tests

There will be three takehome tests. These will look similar to the homework assignments but differ in the following important ways. First, they will be assigned on Friday and due the following Monday **at 5 PM** (except the final which will be available during finals week), and subsequently will be a bit shorter (the corresponding homework assignments those weeks will be shorter as well). Second, you must work on them yourself. You may use the course texts ([DF] and [P]), as well as your course notes. You may *not* use the internet or your peers. They are in theory cumulative, but in practice will reflect material most recently covered.

| | | |
|---|---|---|
| **Takehome Test 1:** | Assigned Friday 2/18 | Due Monday 2/21 |
| **Takehome Test 2:** | Assigned Friday 4/1 | Due Monday 4/4 |
| **Takehome Final:** | Assigned Monday 5/9 | Due Friday 5/13 |

## Grading

Raw grades will be computed* as follows:

| Category | Percentage |
|---|---|
| Homework | 50% |
| Takehome 1 | 15% |
| Takehome 2 | 15% |
| Takehome Final | 20% |
| Total: | 100% |

*Loosely speaking, the A range corresponds to scores in the 90s, the B range to scores in the 80s, the C range to scores in the 70s, and the D range to scores in the 60s. That being said, after evaluating the performance of the class over the entire quarter, I may adjust letter grades according to the median raw score.

## Make-ups and Extensions

If you need an extension on homework or the projects, let me know *as soon as possible*. I like to post solutions ASAP after assignments are turned in, and once they are posted I will no longer accept late assignments. I do understand that we are in the midst of a global pandemic, and things are unpredictable, so communicate with me early and often if you need more flexibility. I will be more flexible with homework assignments than I will with the takehome exams.

## Disabled Students' Program (DSP)

The University of California is committed to providing access, equal opportunity and reasonable accommodation in its services, programs, activities, education and employment for individuals with distabilities. These resources include exam proctoring and accommodations in distraction free environments and with extra time as well as note taking. To request disability accommodation contact the DSP Office at least ten days in advance at (510) 642-0518(V), (510) 642-6376(TTY), (510) 643-9686(FAX), or dsp@berkeley.edu.

## COVID-19 Addendum

We are in the midst of a global pandemic, and everything is unpredictable. As such, things might change rapidly, both in the structure of the course and how we respond to it, and we must be ready to adapt. We may spend some time bouncing between remote and in person, the planned schedule (posted below) may change. **I pledge to be flexible with you!** If you or your family were to become ill don't hesitate to contact me and we will work something out to keep you from falling too behind, or being penalized (no questions asked!). It is most important to stay safe and healthy and prevent the spread.

## Course Schedule

On the next page is a *very rough* schedule of the course, organized weekly. It is very difficult to predict pace for an online course during a pandemic. We may go faster than is laid out over the first few weeks...or slower. We may cover all these things and more, or we may skip some sections due to time. Since projects are specific implementations, their due dates may shift due to timing issues.

| | |
|---|---|
| **Week 1 (1/17-1/21):** | Introduction. Sets, functions, proofs. [P] Chapter 1 and [DF] 0.1 |
| **Week 2 (1/24-1/28):** | Properties of the integers. [P] Chapter 2, [DF] 0.2-0.3. |
| | Definition, examples, and early properties of groups. [DF] 1.1-1.5. |
| | **Homework 1 due Friday.** |
| **Week 3 (1/31-2/4):** | Group homomorphisms and group actions. [DF] 1.6-1.7 |
| | Subgroups, properties, and examples. [DF] 2.1-2.3. |
| | **Homework 2 due Friday.** |
| **Week 4 (2/7-2/11):** | Subgroups and generators. [DF] 2.3-2.5. |
| | Homomorphisms and quotients of groups. [DF] 3.1-3.2. |
| | **Homework 3 due Friday.** |
| **Week 5 (2/14-2/18):** | The isomorphism theorems. [DF] 3.2-3.5. |
| | **Homework 4 due Friday** |
| | **Takehome 1 assigned Friday** |
| **Week 6 (2/21-2/26):** | Group Actions. [DF] 4.1-4.4. |
| | **Takehome 1 due Monday** |
| | **Homework 5 due Friday** |
| **Week 7 (2/28-3/4):** | Sylow theorems. [DF] 4.5-4.6. |
| | Direct products. [DF] 5.1-5.3. |
| | **Homework 6 due Friday** |
| **Week 8 (3/7-3/11):** | Semidirect products. [DF] 5.4-5.5. |
| | Extra topics in group theory. [DF] 6.1-6.2. |
| | **Homework 7 due Friday.** |
| **Week 9 (3/14-3/18):** | Free groups. [DF] 6.3. |
| | **Homework 8 due Friday.** |
| **Week 10 (3/21-3/25):** | *Spring Break* |
| **Week 11 (3/28-4/1):** | Rings, first properties, homomorphisms, ideals. [DF] 7.1-7.4. |
| | **No homework collected.** |
| | **Takehome 2 Assigned Friday.** |
| **Week 12 (4/4-4/8):** | Rings of fractions and the Chinese Remainder Theorem. [DF] 7.5-7.6. |
| | Hierarchy of particularly nice rings. [DF] 8.1-8.3. |
| | **Takehome 1 due Monday** |
| | **Homework 9 due Friday.** |
| **Week 13 (4/11-4/15):** | Principle Ideal Domains. [DF] 8.3. |
| | Polynomial rings. [DF] 9.1-9.3. |
| | **Homework 10 due Friday.** |
| **Week 14 (4/18-4/22):** | More on polynomial rings. [DF] 9.4-9.5. |
| | Introducing fields. [DF] 13.1. |
| | **Homeowork 11 due Friday.** |
| **Week 15 (4/25-4/29):** | Field extensions and algebraic closures. [DF] 13.1-13.2, 13.4. |
| | **Homework 12 due Friday** |
| | *Last day of formal instruction on Friday* |
| **Week 16 (5/2-5/6):** | *Review Week* |
| | **Homework 13 due Friday** |
| **Week 17 (5/9-5/13):** | **Takehome Final Assigned Monday**. |
| | **Takehome Final Due Friday**. |