MATH 4107: ABSTRACT ALGEBRA I  
SPRING 2016 SYLLABUS

**Instructor:** Joe Rabinoff  
**Time:** 2:05–2:55pm, MWF  
**Location:** Skiles 257  
**Course Website:** [http://people.math.gatech.edu/~jrabinoff/1516S-4107/](http://people.math.gatech.edu/~jrabinoff/1516S-4107/)  
**Prerequisite:** Math 2106 or Math 2406  
**Text:** M. Artin, *Algebra*, second edition  
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**Office:** Skiles 221  
**Office hours:** Monday 10am–12pm; Tuesday 2–3pm; and by appointment

**Objectives.** This course is an introduction to the basic concepts in abstract algebra, namely, groups, rings, and fields. These notions abstract out the properties of numbers that are important for doing arithmetic (or “algebra”), and are ubiquitous in pure and applied mathematics as well as computer science and theoretical physics. That said, this is a course in pure mathematics — we will touch on a few applications, but that is not the main thrust of the course. Students will be expected to learn a number of abstract definitions, to understand their basic conceptual properties, to learn the nontrivial theorems concerning these objects (and their proofs), and to correctly apply these theorems, concepts, and definitions to prove new (i.e. not previously seen) statements in the theory. After taking the course, students will be prepared to take higher-level courses in abstract algebra, algebraic number theory, algebraic combinatorics, and related topics.

**Prerequisites.** This course is meant for students who are already comfortable writing proofs. We will not spend any class time on how to write proofs; this is the reason for stipulating Math 2106 as a prerequisite. If you are not comfortable writing proofs, I recommend taking Math 2106 first. Taking a class like this without a background in proofs is like taking a course on Proust without having studied French. Essentially all of the work on which you will be evaluated will be some form of written proof.

**How to succeed in this course.** This course is meant to be challenging, as you would expect from a course aimed at upper-level math majors at Georgia Tech. Here is the best advice I can give for how to do well. This advice applies to most classes in pure math.

1. **Spend enough time outside of class thinking about the material.** Abstract algebra, like anything else in pure mathematics, simply takes a lot of time to learn. Accordingly, this is the single most important thing you can do to succeed. The meaning of ‘enough time’ depends on your background and varies from person to person, but you should expect to spend 5–10 hours outside of class each week. If you are taking five other difficult courses, this may not be the class for you. Historically, peoples’ final grades depend almost linearly on the amount of time they put into the class.

   Remember, a person who can do abstract math is generally just a person who has spent a lot of time thinking about abstract math, in exactly the same way as a marathon runner is just a person who has run a lot of miles in training.
(2) **Do every problem on every homework assignment.** The only way to learn math is by practicing; hence the homework is by far the most important component of the course (see below). After you puzzle through several difficult problems (at the cost of several hours each, perhaps), you will gain confidence in your own problem-solving abilities, which will be improving.

(3) **Get productively stuck.** It does not count as real problem solving if it only takes a minute or two to figure out the next step. When you do get stuck (and you will), do not give up or get frustrated: look through your notes and the book, pay attention to the definitions and the theorems, understand the proofs to see if any of the techniques apply in your situation (they often will), make sure you’re using all of the hypotheses in the statement of the problem, try a few examples, etc. Sometimes the best thing to do is stare at the paper and just think really hard. It may seem like you’re not getting anywhere, but this kind of being stuck is in fact very productive.

(4) **Collaborate on the homework.** It’s more fun and more effective to be productively stuck with a classmate or two. Almost everyone will learn faster if they work on the homework problems with someone else — this is the best (really, only) way I know of reducing the amount of time it takes to learn the same amount. Here I mean you should work through the problems together; you will learn very little by copying someone else’s solution. In any case, you must write up your solutions separately; see below.

(5) **Don’t look on the Internet for answers.** While it’s not forbidden (see below for the policy), Googling the answer is not a good way to learn: it shortcuts (1) and (3) above. I personally grade much of your homework assignments, and it is generally easy to tell when an answer was found on the Internet: because the logic is garbled, the notation is inconsistent, the argument is circular or uses results not covered in this course, etc. Plus, you’re shooting yourself in the foot come exam time. If you want to do your homework faster, see (4) above.

(6) **Come to office hours.** I am a college professor in part because I honestly enjoy interacting with students. I’m here to help with the class, and especially the homework. **Come prepared** with questions you’ve already spent a good time thinking about, and I’ll show you other ways of thinking about the same thing, correct any misunderstandings, and point you in the right direction. Don’t expect me to simply tell you how to do the problems; this is not a good way to learn.

(7) **Come to class.** Even if you don’t like my lecturing style, we will do problems in class which will be closely related to problems on the homework, so it’s still worth your while to show up. If you are obliged to miss a class period, please let me know so I can help you get caught up.

(8) **Read the book.** I learned the subject from the first edition of Artin’s *Algebra*. It is an excellent resource.

**Homework.**

- The weekly homework is the **most important component** of the course; as such, it will be heavily emphasized in the grading scheme (below).
- There will generally be a homework assignment due every Wednesday, at the beginning of class. **This includes the final days of instruction.** The idea is that you’ll do most of the homework over the weekend, then come to office hours on Monday and/or Tuesday. I do not expect you to be able to complete the homework on the night before it is due.
- Late homework will generally not be accepted.
- Several problems on the midterms and the final will be copied verbatim from the homework assignments.
- All solutions must be neatly written in grammatically correct mathematical English.
- Collaboration on solving homework problems is **encouraged**, as mentioned above; however, **you must write up your work separately**, so your proofs will not be identical word-for-word.
• Please list your collaborators and any outside sources you consulted on all graded work. This is a matter of academic honesty: standing on the shoulders of giants (or classmates) is fine, but you cannot tacitly take credit for other peoples’ ideas. You may consult any sources you can find, including those on the Internet, but you are discouraged from using anything other than your class notes and the text; see note (5) above.

• I will not post solutions to homework problems. In my experience, when students do read posted solutions, they learn about as much as they would by Googling the question, which is to say, not very much. If you want to know how to do a problem on a previous assignment, come to office hours and ask your classmates!

• If you start the homework early, collaborate with your classmates, talk to me in office hours, and commit the necessary time, there is no reason you should do poorly on the homework.

Exams.

• There will be two in-class midterm exams.
• The final exam will be held at the place and time scheduled by the Institute for that purpose.
• There will be no aids (textbook, calculator, etc.) allowed on the exams.
• Absences from the midterms are generally excused only for Georgia Tech official business, religious holidays, serious illness, and the like. This does not include internships and interviews. I reserve the right to ask for a letter from the Dean of Students to justify an absence.
• In the event that you miss the midterm for an acceptable reason, you will be excused from that exam; the other midterm, homework, and final will count more towards your grade.

Course structure. This course is organized around making efficient use of classroom time. In order to accomplish this, I will require you to spend some time (maybe 30 minutes to an hour) reading the text before each class. This is to avoid spending class time covering routine definitions and lemmas, which you don’t need a math professor to explain to you. I expect you to read the statements of the theorems, but not necessarily to absorb the proofs. There will be a short reading comprehension quiz due at 6pm the evening before each class. The last question on the quiz will always be:

What did you find most confusing in the reading? What would you like to see explained in class?

Each class period will be roughly divided into thirds.

(1) First I’ll try to clarify the points that people found most confusing, as determined by the answers to the question posed above. I’ll also cover the interesting proofs from the reading.

(2) Next you’ll do exercises and examples in small groups, on the material just discussed. Many of these exercises will either appear verbatim on that week’s homework assignment, or at least will form a special case or an example of a homework exercise. This is also a good opportunity to meet classmates to work with outside of class. I’ll circulate the room, answering questions and trying to explain the subtle points.

(3) In the third half of the class I’ll give an overview of the material to be covered in the upcoming reading assignment. This will include motivation, and statements of the main results.

This is my first time organizing the course in this manner, so course organization may change. I’ll be requesting feedback after a few weeks.

Honor code. Students are expected to fully adhere to the honor code, which can be found at

http://www.honor.gatech.edu/

Note that writing up your homework separately and listing your collaborators are matters of academic honesty.

Important dates. The midterm dates are tentative; they will be confirmed at least a week in advance.
February 12      Midterm exam 1
March 11        Midterm exam 2
March 16       Last day to withdraw from course
April 28 – May 5 Final exam period

**Grading.** The grade breakdown for the course is as follows:
- 25% Homework assignments
- 5% Quizzes
- 20% Midterm exam 1
- 20% Midterm exam 2
- 30% Final exam

The final letter grade cutoffs will be determined *after* all number grades have been determined. However, if you score at least 90% in the class you will be guaranteed an A, 80% for a B, and 70% for a C.

**Outline.** Below is a rough course schedule with corresponding chapters of the text. We will follow the text rather closely. The midterm focuses on the unit preceding it, whereas the final exam is comprehensive.

*January 11 – February 26:* Group theory. Chapter 2: subgroups, homomorphisms, quotient groups, counting formula, correspondence theorem. Chapter 6: symmetries, group actions. Chapter 7: the class equation, the Sylow theorems, classification of groups of small order.


*April 4 – April 25:* Field theory. Chapter 15: finite field extensions, irreducible polynomials, finite fields, the primitive element theorem.