Syllabus

This syllabus contains important information about the course, including its goals, assignments, policies, resources, and expectations.

Communication and Office Hours

Important: While I appreciate your enthusiasm for discussing mathematics, please save mathematical questions for classes, sections, and office hours. For matters not directly related to course content, I am happy to communicate by email.

Canvas: All announcements will be managed through Canvas.

Instructor: Dimitri Navarro (he/him). You may call me Professor or Dimitri.

Email: dnavar17@ucsc.edu

Office: McHenry Library, Office 4192

Office Hours: Mondays from 2:00 to 3:30 pm and Wednesdays from 10:30 am to 12:00 pm, McHenry 4192.

Purpose → I am happy to answer questions about the course or assignments, review prerequisite material, or discuss more advanced topics. There are no stupid questions, and you do not need to arrive with anything specific in mind. You are welcome to come listen, study, or work through ideas with your peers.

TA: Mike Williams

Email: mijawill@ucsc.edu

Office: McHenry Library 1266/1261

Office Hours: Tuesdays and Thursdays from 2:00-3:00pm, McHenry 1261.

If these times don't work for you, feel free to schedule a meeting with Mike.

Course Goals

The main goal of this course is to introduce you to classical geometry from both a historical and a modern point of view. We will begin with Euclid's *Elements*, studying both the power and the limitations of Euclid's treatment of geometry. From there, we will move toward a more rigorous axiomatic framework through

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Hilbert's axioms, and we will see how questions surrounding the parallel postulate eventually led to the development of non-Euclidean geometries.

By the end of the course, you should be able to read and write geometric proofs, carry out and justify straightedge-and-compass constructions, distinguish clearly between intuition and rigorous argument, and understand several concrete models of Euclidean and non-Euclidean geometry. More broadly, the course aims to develop both your geometric intuition and your ability to express mathematical ideas clearly and rigorously.

I look forward to a wonderful quarter together!

Prerequisites: Either MATH 100 or CSE 101.

Classes and Sections

Important: If any part of the course is inaccessible to you, please contact me so we can discuss accommodations and ensure your full participation.

Classes: TuTh 3:20–4:55 pm, Cowell Clrm 131.

Format → Class meetings will combine the introduction of new material with problem-solving activities designed to reinforce and deepen your understanding.

Sections: Wed 2:40–3:45 pm or 4:00–5:05 pm, McHenry Clrm 1267.

Format → Each section will be based on a worksheet. The class will be divided into groups, each assigned one special problem. Groups will work collaboratively for the first 40 minutes; in the final 20 minutes, each group will give a 5-minute presentation on its special problem.

Purpose → These sessions are designed to help you strengthen key mathematical skills: (1) problem-solving, (2) collaboration, and (3) oral presentation.

Remark → Presenting your work can feel daunting at first, but it is an essential skill developed only through practice. These sessions are low-stakes and ungraded—they exist to let you experiment, make mistakes, and learn together. Everyone (including me!) will make mistakes, so let us keep these sessions open, supportive, and fun.

Lecture Notes, References, and Tools

Important: You will access the course materials via our Ximera course page. I created this site to make the course materials as accessible as possible. My LaTeX files are automatically converted into HTML and posted there, so they can be read by screen readers. On the site, you will find the lecture notes and worksheets for the course.

Notes: I aim to post the lecture notes within one day of each class.

Recordings: You may access class recordings on YuJa (left panel in Canvas).

References: This course draws on several books and online resources. In particular, I will use:

(i) David E. Joyce's online edition of Euclid's *Elements*. This website provides free access to a beautifully presented online version of Euclid's *Elements*, together with diagrams and commentary.

(ii) Marvin J. Greenberg, *Euclidean and Non-Euclidean Geometries: Development and History*

(iii) Robin Hartshorne, *Geometry: Euclid and Beyond*

(iv) David W. Henderson and Daina Taimiņa, *Experiencing Geometry: Euclidean and Non-Euclidean with History*

(v) Ana Irene Ramírez Galarza and José Seade, *Introduction to Classical Geometries*

Most of the course will focus on (i), (ii), and (iii). During the first part of the course, we will spend time reading portions of Euclid's *Elements* through (i), where we encounter the first great attempt at a rigorous treatment of geometry. Euclid's constructions and ideas, but also his oversights and lack of rigor, will serve as a guiding thread toward a more precise treatment of geometry through Hilbert's axioms. They will also help us understand the two-thousand-year effort to prove the parallel postulate, which eventually led to the development of non-Euclidean geometries. I will rely on (ii) for its historical perspective and philosophical approach, and on (iii) for its rigor and its rich collection of exercises.

If time permits, I would also like to spend some time on (iv), which offers a very hands-on approach to a variety of geometric concepts on a broader class of spaces than Euclidean or hyperbolic geometry alone. I would also like to present a few aspects of Klein's point of view on geometry through group actions, which provides a beautiful unifying framework for thinking about what geometry is.

Dynamic Geometry Tools: One of the main goals of this course is to become acquainted with straightedge-and-compass constructions. While I strongly encourage you to purchase a ruler and a compass and to carry out constructions by hand on paper, the tools described below add a dimension that paper-and-pencil constructions cannot provide: they allow you to move points and lines dynamically and observe how a construction changes under such variations.

(ia) GeoGebra. GeoGebra is freely accessible online and is especially well suited to two- and three-dimensional Euclidean geometry. You may create an account and save your constructions, and there is also an iPad app if you prefer to work that way.

(ib) GeoGebra Classic. A more powerful version of GeoGebra which allows you to also create new tools.

(ii) Spherical Easel. Spherical Easel is, in spirit, a kind of GeoGebra for spherical geometry. It allows you to create and save interactive spherical constructions and is particularly well suited to experimenting with great circles, spherical triangles, and other objects of spherical geometry.

(iii) Cinderella. Unlike the previous two tools, Cinderella is software that you install and use locally rather than a web-based platform. It is a beautiful and powerful tool for two-dimensional Euclidean, hyperbolic, and elliptic geometry, though it is somewhat less intuitive at first than GeoGebra or Spherical Easel. We will use it in particular when we begin our study of hyperbolic geometry.

The purpose of these tools is to help us visualize geometric phenomena, explore examples, and test conjectures, but they are not a substitute for careful reasoning and proof.

Tentative class schedule: I will do my best to follow the schedule below.

Week	**Content**
1	Introduction to the class and Euclid's Elements Book 1
2	Euclid's Elements Book 1 and 2
3	Euclid's Elements Book 2 and 3
4	Euclid's Elements Book 3 and 4
5	Hilbert's axioms of Incidence I1, I2, and I3 and Midterm Exam
6	Finite geometry
7	Affine planes
8	Projective planes
9	Transformations
10	Pappus Theorem and back to Euclid's Elements

Table 1: Tentative Class Schedule

Assignments & Assessment

Homework (40%): Homework will be released weekly on Thursday and due the next Thursday. During exam weeks, different dates may apply. You will access your homework and submit your work via Canvas. Homework may be submitted either handwritten (clearly scanned as a single PDF) or typeset in LaTeX. While you should always answer a problem in your own words, I strongly encourage you to discuss the problems with your classmates.

Midterm Exam (25%): The midterm will take place on **Thursday, April 30th (week 5), at the usual class time and in the usual classroom.**

Final Exam (35%): The final exam will be on **Thursday, June 11th from 12:00 to 3:00 pm in the usual classroom.**

Excellent	Good	Satisfactory	Poor	Failing
A+ (95–100)	B+ (80–84)	C+ (65–69)	D+ (50–54)	F (< 40)
A (90–94)	B (75–79)	C (60–64)	D (45–49)	
A- (85–89)	B- (70–74)	C- (55–59)	D- (40–44)	

Table 2: Grading Scale

Feedback

Instructor and TA Feedback: Mike and I will provide direct comments and feedback on your assignments.

Weekly Student Feedback: Most homework assignments will include a bonus question inviting you to comment on the course, describe concepts you find difficult, and reflect on your own learning. Your responses will be anonymous and will help me adjust my teaching throughout the quarter. Please share what is working well for you and what could be improved.

End-of-quarter Feedback: At the end of the quarter you will be asked to complete a Student Experience of Teaching survey for this course. SETs provide an opportunity for you to give valuable feedback on your learning that is honest and constructive. This anonymous feedback will help me consider modifications to the course that will help future students learn more effectively.

Policies: Course, Grading, and AI

Grading Homework: You are welcome to use LaTeX to write your answers, although handwritten submissions are equally acceptable. Emphasis should be placed on the presentation and clarity of your reasoning. In grading, I value the process over the outcome: partial credit will be awarded for sound reasoning, even if the final answer is incorrect.

Homework Corrections: You may revisit graded homework and submit corrections to recover up to full credit. Read the feedback and posted solution, then explain in your own words what was incorrect or incomplete in your original answer and how to correct it. Include a corrected argument; simply copying the posted solution is not sufficient. Email your corrections to Mike and me and submit a regrade request for the corresponding question. The purpose of

this policy is to encourage you to use feedback, learn from your mistakes, and revisit earlier material throughout the quarter.

Late & Skipped Homework: I understand that life can be unpredictable and sometimes unexpected events might interfere with your ability to submit assignments on time. If you find yourself in such a situation, please reach out to me *at least one day before the assignment's due date*.

Make-Up Exams: I am aware that unforeseen events may prevent you from attending the exams. If you find yourself in such a situation, please reach out to me as early as you can. We will work together to find a suitable solution such as a make-up exam.

Generative Artificial Intelligence: You are allowed to use AI tools (such as ChatGPT) provided you clearly disclose how you used them. If you choose to use AI for an assignment, please include both the prompts you entered and a brief explanation of how the AI assisted you. AI should be used to support your learning rather than replace it. Appropriate uses include asking for clarification of concepts, requesting additional practice questions, checking your understanding, or receiving feedback on your own written attempts. In contrast, it is not appropriate to paste homework problems into an AI tool and copy its solution, or to rely on AI to write up homework that you then submit as your own.

The goal of this course is to develop your own mathematical thinking. AI tools make mistakes, especially in mathematics, and over-reliance on them can prevent you from mastering the material. Moreover, a majority of your grade—coming from the midterm and final exam—will be based on assessments in which AI cannot be used. Genuine understanding is therefore essential. I encourage you to use AI in ways that make you smarter, not in ways that make you dependent.

Student Services and Accommodation

Small Group Tutoring: Small Group Tutoring provides a small interactive setting for students to be comfortable engaging in conversations about course material with other students. Each session is led by a current UCSC undergraduate student who has taken the course and done well in it. Tutoring sessions are 1-hour long and generally have a capacity of 6 students. When students sign up for tutoring, they make a commitment to attend tutoring weekly for the entire quarter. All students can sign up for up to 2 sessions of tutoring a week per course they are enrolled in.

Academic Excellence (ACE) Program: For over thirty years, the Academic Excellence (ACE) program has been increasing the diversity of students earning their bachelor's degrees in science, technology, engineering, and mathematics (STEM) at UC Santa Cruz. ACE advances educational equity by engaging students in active learning, peer mentoring, skill-building, and community de-

velopment.

DRC accommodation: UC Santa Cruz is committed to creating an academic environment that supports its diverse student body. If you are a student with a disability who requires accommodations to achieve equal access in this course, please affiliate with the DRC (by phone at (831) 459-2089 or by email at drc@ucsc.edu). For students already affiliated, make sure that you have requested Academic Access Letters, where you intend to use accommodations. You can also request to meet privately with me during my office hours or by appointment as soon as possible. I would like us to discuss how we can implement your accommodations in this course to ensure your access and full engagement in this course.

Religious Accommodation: UC Santa Cruz welcomes diversity of religious beliefs and practices, recognizing the contributions differing experiences and viewpoints can bring to the community. There may be times when an academic requirement conflicts with religious observances and practices. If that happens, you may request reasonable accommodation for religious practices. I will review the situation in an effort to provide a reasonable accommodation without penalty. You should first discuss the conflict and your requested accommodation with me early in the term. We may also seek assistance from the Dean of Students Office.