MATH 304: Geometric Structures - Dr. Miller - Syllabus - Spring 2025, CRN 3181

Keep this syllabus with your course handouts. You are responsible for reading it entirely. It is subject to change in extenuating circumstances.

Meeting Times/Place: MW 3:00-4:15 in ATS 129

Course Description/Content: Finite & infinite axiomatic systems, including Euclidean and projective geometries

- This course builds heavily on proof-writing skills from Foundations of Proof and is very VERBAL.
- A key theme is using logic to deeply understand geometric concepts and learn why looks can be misleading.

Prerequisites and Follow-Ups:

- Prerequisites: C or better in MATH 235 - Modern Concepts
- A course on this material is required for Pennsylvania teacher certification.

Text/Print Resources: *Foundations of Geometry*, THIRD edition, by Gerard Venema (ANY format is fine)

- We also use some out-of-print material that I will provide to you. (Copyright fair use clause)

Personal Environment: I go by my middle name with friends and Dr. Miller in professional settings, so I am sensitive to what other people want to be called. Please let me know your preferences.

Classroom environment:

- No food in the lab; I can't allow some drinks (especially nut-flavored) due to SRU-documented disability.
- See me if these restrictions conflict with your own documented accommodations.
- I teach using at-the-board lecture and a few activity hand-outs. You might also present informally.
- Don't distract yourself with cell phone use or off-topic chatter during class.
- **Protect necessary study time *outside* class.** HW in proof classes requires many hours each week.

Student Hours and Contact Info: Email: lyn.miller@sru.edu - Phone: 724-738-2878 - Office: VSC 200-B

- Drop-in Student Hours: **MTWF 10:30-11:30am (so not Thursdays) and F 2-4pm**
- I can make appointments outside of listed office hours, and if my door is open, I'm available "by capture."
- **Course assignments are posted on our web page (not D2L) at granite.sru.edu/∼lmiller .**
  - I only use D2L for things that need to be private: your grades, copyrighted handouts, etc.
- Email is my preferred communication with you, and here are some general guidelines:
  - I check SRU email every weekday morning, but I am in class/meetings roughly 12:30-4 daily. I can check afternoon emails when I end the day around 4:30-5pm.
  - I try to acknowledge emails that same day, but may need another 1-2 business days to take action, depending on time of day, other responsibilities, and whether anyone else must be looped in.
  - Evenings/weekends, I try to model professional boundaries and etiquette: neither you nor I should expect replies to after-hours emails, unless we've made prior arrangements.
  - I will notify everyone ASAP about any unexpected issues; I ask that you do the same (absence, etc.).

Technology: (Calculators are allowed, but you'll rarely ever need one.)

- We'll work some with Geometer's Sketchpad (GSP) for drawing, teaching, and learning geometry.
- It is installed in this lab, and we'll get it for study areas too, if possible.
- I don't believe personal copies are available any more; GSP is not free anyway.
- It has features in common with Geogebra, a free web-based app, but Sketchpad is superior.
- Exams and HW may include some assessment of your technology skills.

General Grade Structure: Cut-offs are $A = 90-100\%; B = 80-89\%; C = 70-79\%; D = 60-69\%; F = 0-59\%$.

- Course total = tentatively 600 points, coming from these items:
  - (*) HW Score = 100 pts - due weekly, 20 points each, lowest 2 dropped and rest scaled to 100 pts
  - (*) Mid-Term Exams = 300 pts total - 100 pts each, roughly one per month
  - (*) Final Exam = 150 pts - cumulative, may have some points replaced by a History Project
  - (*) Technology Projects = 50 pts - due about every 2 weeks, none dropped, scaled to 50 course points
  - (*) TENTATIVE History Project = up to 30 pts, replacing points from Final Exam
- Point values and frequency of items may be changed if circumstances merit it.
  - For instance, the 150-pt total between HW and Tech projects may split differently if we end up with fewer tech projects
  - Or, as noted above, the Final Exam may have some points converted to a History Project.
  - The history component will be decided yes/no by Spring Break, as I see whether our pace through the required math content can support an add-on history component.
  - Students with SRU-documented test or HW accommodations should notify me ASAP.

Homework (HW): Turned in weekly, worth 20 points each, 2 dropped, remaining scaled to 100 course pts

- HW is usually due on Fridays late afternoon; proofs take MUCH time, so start early!
- I give a list with a 5-7 day window before it's due. Try to start that same day.
- Please staple, remove ragged edges, write legibly (or TeX), and leave LOTS of room for me to comment.
- I grade a selection among the problems each time, for correctness and rigor (we'll define this term).
- **Make-up/late policy:**
  - I approve make-up HWs only for University-recognized reasons (illness, SRU travel, etc.) and only with discussion ASAP and official documentation (doctor's note, obituary, etc.)
  - Depending on the situation, I may double-count a future assignment as your make-up score, rather than accepting the original assignment too late to give good feedback to the rest of the class.
  - Remember, dropping 2 scores allows for undocumented travel, illness, etc., or just "a bad week"
  - Late HWs: In extenuating circumstances, I do grant basic extensions, but you MUST speak with me in advance, and often there is a deduction.
  - Late assignments submitted without my approval will be penalized, up to not grading them at all.
- Turning in HW early or via email when you'll be absent is usually approved, but ask first.
- You may collaborate on HW, but **do not COPY** from others, the web/AI, books, etc.
- **Inappropriate collaboration may result in a score of 0 for all involved, regardless of intent.**
- Solutions (sometimes partial) will typically be posted outside my office door and on D2L.
- To honor copyright laws and other restrictions, do NOT share solutions beyond our course.

Mid-Term Exams: Worth 300 points total: 100 each for Exam #1, #2, #3, no collaboration

- Midterm exams cover everything since the last exam, but I also give a printed Topics List 1 week in advance.
- Parts of this course are cumulative, so be prepared to use earlier skills on exams too.
- Answers without work/support do not earn full credit. Justifications and proofs must be rigorous.
- Justifications/work/proof are graded on correct MATH knowledge, notation, reasoning, and style.
- Honesty and integrity are expected; violations may result in a 0 for all involved.
- Tentative dates are on the course calendar on our web page.
- Students with SRU-approved accommodations must submit ODS requests one week in advance.
- Exam solutions are posted outside my office door and on D2L after grading.
- **Make-up Exams**: approval requires a documented, SRU-recognized reason and meaningful efforts to contact me in advance.
  - If I approve your make-up score, you won't actually take an immediate replacement exam, adding stress to a likely already stressful return to class.

– Instead, your percentage on the relevant material when it shows up on the cumulative Final Exam will fill in for your missed midterm exam score. Study that doubled material extra well!

Final Exam: cumulative, worth 150 course points total, no collaboration, honesty/integrity expected

- You MUST take the Final at the scheduled time: **FRIDAY, May 9, 1:00-3:00 pm** (in this room)
- Students with SRU-approved accommodations must submit ODS requests one week in advance.
- Final exams are not returned to you, and grades typically take 3-5 days to finalize.

Technology Projects: 50 pts, scaled; none dropped

- Tech projects will be due on 4-5 occasions, sometimes 2 projects together.
- At semester's end, the overall score will be scaled to be worth a total of 50 course points.
- Projects may have different point values, depending on how many skills are combined within each: a project using only basic skills is worth less than a project needing multiple geometric reasoning justification in advance.
- They are due roughly every 2 weeks, beginning about the 3rd-4th week of the semester.
- The needed software, Geometer's Sketchpad, is not free, but SRU owns a site license.
- GSP is installed in our classroom, and I can arrange to have it installed on a few machines in other rooms that would be convenient for your use.
- We'll discuss the best additional locations as a class.

POSSIBLE History Project: up to 30 pts replacing points in the Final Exam

- The decision on whether we'll tackle history projects will be made by Spring Break.
- The format - written versus oral - will also be decided then, along with a list of possible topics.
- If oral, the project will have teams of 2-3 work together. If written, it may be individual.

Attendance and Help:

- I take attendance daily, but it does NOT count toward your grade.
- If you are absent, get the notes from a **classmate**. This is **YOUR** responsibility.
- Handouts and announcements are available via my web page **granite.sru.edu/~lmiller**.
- **The Department does not in general provide peer tutoring for this course.**
- You can get help from me during student hours (above) or by appointment.
- You can also work together but don't just copy: even if the whole group likes a common answer, write it in your OWN words and notation to hand in.
- SEEK HELP EARLY AND OFTEN!

Student Outcomes - Math 304: Geometric Structures

(SRU Department of Mathematics - Spring 2014 PDF version)

1. Students will demonstrate an understanding of and competence in working with logic. This includes the following topics:
   (a) Informal logic (b) An introduction to axiomatics and proof (c) The role of examples and models
2. Students will demonstrate an understanding of and competence in working with Hilbert's Axioms. This includes the following topics:
   (a) Axiom of betweeness (b) Axiom of congruence (c) Axiom of continuity (d) Axiom of parallelism
3. Students will demonstrate an understanding of and competence in working in Neutral Geometry. This includes the following topics:
   (a) Alternate interior angle theorem
   (b) Exterior angle theorem

(c) Angle measure and the ruler and protractor postulates

(d) Pasch's postulate

(e) Saccheri-Legendre theorem

(f) Angle sum of a triangle

4. Students will demonstrate an understanding of and competence in working in Euclidean Geometry. This includes the following topics:

   (a) Equivalencies of the parallel postulates

   (b) Congruence criteria

   (c) Similar triangles and Pythagorean theorem

   (d) Cirdes and polygons,as time permits

5. Students will demonstrate an understanding of and competence in working in Non-Euclidean Geometries. This includes the following topics:

   (a) History of discovering of non-Euclidean geometries

   (b) Hyperbolic geometry

   (c) Beltrami-Klein model

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Important University-wide policy statements:

Title IX: Slippery Rock University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to meet this commitment and to comply with Title IX of the Education Amendments of 1972 and guidance from the Office for Civil Rights, Title IX requires University faculty members to report incidents of sexual discrimination, including sexual violence, shared by students to the Universitys Title IX Coordinator. Accordingly, if a student shares information about any incidents of sexual discrimination or sexual violence during a classroom discussion, in a writing assignment for a class, or in other contexts, faculty must report that information to the Title IX Coordinator. This information will only be shared with the Title IX Coordinator, who is the individual on campus designated to respond to reports of discrimination or sexual violence. While the Title IX Coordinator is not a confidential source of support, they will address matters reported to them with sensitivity and will keep your information as private as possible.

Additionally, faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred, to the person designated in the Universitys Protection of Minors Policy.

Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth at: https://www.sru.edu/offices/human-resources-and-compliance/sexual-misconduct-and-title-ix-resources

Slippery Rock Universitys Title IX Coordinator is Karla Fonner and she can be reached at karla.fonner@sru.edu; 724-738-2953, or you can submit a Care Referral with the details of the situation.

Non-discrimination: Slippery Rock University of Pennsylvania does not discriminate on the basis of race, color, sex, sexual orientation, gender identity, gender expression, national origin, religion, age, disability, or veteran status in its programs or activities in accordance with Title IX of the Educational Amendments of 1972, the Americans with Disabilities Act of 1990, Section 504 of the Rehabilitation Act of 1973, Title VII of the Civil Rights Act of 1964, and other applicable statutes and University policies. www.sru.edu/offices/diversity-and-equal-opportunity/notice-of-non-discrimination .

More Info about proof-based math courses and the philosophy for taking them

- **What This Course Is About, Why You Need It, and How It's Taught**

Content and Rationale: To mathematicians, the word "proof" has a very deep meaning that is often difficult to define. A proof is not just a list of computations that ends up with some numeric result or in some desired form of symbols. Rather, **a proof is a clear, connected set of mostly verbal statements (though often mingled with equations or other notation) that completely justifies why some particular behavior will happen or some property will be true**. Writing a proof is the art of nailing down a guarantee in some sense about things that are not always specific. Key purposes of most proof-based courses are to help you (1) identify what your "guarantee" claim really is in any given reasoning setting, (2) recognize sentences or notation that MUST be included in order to meet the aim of "connecting" your proof's statements, and (3) sharpen your attention to verbal and notational detail that will make your proofs "clear" and "complete," without any gaps in reasoning. FORMAL use of language and notation aren't just nit-picky choices by one instructor vs. another, but rather are the true building blocks of mathematical proof in all courses.

It can be tough to make the switch from computational-type thinking and work that served you well in courses like algebra and calculus, to grappling simultaneously with both the information that you need to say AND the way you need to say it, and many math students say that writing proofs is one of the hardest things they try to learn. It is also extremely satisfying, though, like learning any new but challenging skill: reading and writing proofs opens the doors to understanding WHY so much of what we were taught in grades K-12 really is true or has to work in a particular way. Proof makes SENSE of rules that many people just grudgingly accept as somebody's annoying whim. And mathematics at its most basic could be described as making sense (predictions, rules, guarantees, truth!) of the world around us.

Proof-writing benefits anyone going into a mathematical career. Teachers definitely need to know and be able to justify WHY so many properties that they teach are innately true, rather than just "that's how you're supposed to do it" rules. Even if the justification isn't one you could share with students, you will be able to use it in thinking about their questions of curiosity: "Teacher, what happens if we...?" or "I did it differently and got the same answer. Will that always work?" or "Why can't we...instead?" College math majors going into non-teaching careers benefit from proof-based coursework, too. Employers in industry (actuarial or statistical consulting, systems management/optimization, etc.) value employees who can give clear explanations and justifications for their actions or their conclusions in a proposal, especially in communications with a non-expert client or company stakeholder. Though such jobs don't require you to write abstract proofs, employers want people who can recognize when an idea or explanation makes sense or not, who can analyze whether some new plan will work and WHY, and who can communicate their reasoning in a way that is connected and leaves no gaps, guesses, or "well, it worked in this one situation, so let's do it that way all the time" over-simplifications.

Pedagogy: In any proof-based course, YOU will definitely be writing lots of original proofs. On my end, I still lean toward the lecture-as-model style of teaching, with a lot of discussion thrown in. I teach in this manner because I hope it lets you slowly work through each step of a proof as we build general styles that will be needed in many of your further courses. In additional to learning specific math content in an upper-level proof course like this one, you'll also be learning specific reasoning *patterns*. So to see enough examples to recognize a pattern, lecture can give you a model for how the material is logically organized and how it flows most clearly and even elegantly. However, there's also a potential weakness to lecture: during a polished lecture, even an excellent one, you typically don't get to see the professor DOING mathematics; you only get to see him/her PRESENTING mathematics. Most students may not realize that there's a difference. So we math professors face a dilemma: how do we in the same course demonstrate often what a good finished product of a proof should look like while also demonstrating how to arrive at one from scratch, with all the fits and starts, back-tracking and just plain re-booting that the process entails? There are a lot of valuable approaches and philosophies for attempting this, but in the end, most math faculty agree that we should each teach according to our own strengths. For me, that is still presenting proofs and techniques at the board with lots of discussion about the rationale for each step, and expecting you to internalize that rationale (with note-taking!) so that you can recognize and use it in similar situations in this class and others. I hope this teaching technique will be successful in helping you to learn the material and the broader reasoning and proof skills the course is used to develop.

Sources of Help: Remember, you are allowed and encouraged to study together for this course, but make sure you write up assignments in your own words. Please refrain from using solution manuals or web searches to look up answers or solutions. Doing so deprives you of the opportunity to improve your own skills. (By the way, generative AI sites write TERRIBLE proofs! They probably wouldn't pass my course, so don't trust them.) And as I've often been told that my exams require students to "think on their feet," losing out on genuine individual practice will probably put you at a keen disadvantage for exams.

Since this is an upper-level course, the Department does NOT provide peer tutoring for it. A peer tutor doesn't yet have the sufficiently broad and deep views of proof-based mathematics needed to be effective. It would put unfair pressure on them to expect that. If you need help, please come see me during Student Hours, or we can make an appointment. For this course in particular, I have an "open door" policy, meaning that I'm willing to help you outside posted Student Hours if I am free. So if you need help but it's not my scheduled hours, you can certainly ask if I can help. If I'm not in the middle of another commitment, I will take time to work with you. If you see my door physically open, it usually means that I know I can interrupt other tasks to focus on you.

Criteria/Expectations: HW and exam scores reflect how well you understand the course content, and that means concepts – ideas, relationships, vocabulary, proof structure, etc. – not just algorithms that move numbers and symbols around. Therefore, on homework and exams, I expect that you will, among other things:

Show correct, complete work on computationally-based problems: I often award partial credit for some correct work even with a wrong answer; conversely, if your work for a problem is wrong, incomplete, or missing, you will earn very few points even if you got a correct value or expression in the end. Also be sure you actually answered the question or drew a conclusion. For instance, if a problem asks you to find a total number of people, and you only tell me - separately - about how many adults and how many children, you haven't completed the task.

Give clear verbal justifications when asked, and write rigorous proofs: Verbal justifications and proofs are the main content of this course. Students are sometimes surprised by the very high quality I require in order to earn full credit on them. Your informal justifications or explanations *will* be verbal/words, not just lists of computational steps. You must aim for the calibre of a future professional supporting the method or explaining the material, NOT of a high-schooler showing their scratchwork or describing their thinking. You should also be showing or writing about the necessary MATH in a problem, not about your internal train of thought. Unhelpful statements such as "I just kept trying numbers until it worked" or disorganized steps whose order makes sense only to you are unlikely to be worth many points as a justification or explanation.

The most frequent verbal component of this course is proof-writing. Proofs require **rigor, a term that means (1) you have no errors in the logic connecting your ideas/statements and (2) you have not skipped any steps in reporting those connections**. Recognizing what rigor is, and what it does or does not look like, are skills this course helps you expand on beyond the Foundations course, so I will provide plenty of coaching. Be aware that the ultimate goal is to have you develop a sense of when you have been rigorous in writing a proof, so that you avoid logic errors and skipped reasoning in later courses.

Apply critical thinking: Fully comprehend instructions: what I ask for IS what you'll get points on, no more, no less. I see two kinds of mistakes here: first, sometimes students don't think about or don't understand the ordinary English vocabulary. For instance, the definition of "explain" implies to use words, so if you merely list equations or computations with no verbal discussion to connect them, you will earn 0 points because you didn't give an actual explanation. Second, I assess for you're-going-into-this-profession-someday skills. So for example if a question says to demonstrate one technique but you show another, again you will get few points because the point of the question is not just to get a final answer any old way, but to demonstrate the ability to adapt your approach and have a large and varied toolbox of skills (necessary from a professional).

Behave with integrity: In your professional life, the people you deal with will expect you to be honest with them, maintain standards, and not cut corners. Establishing those traits early and solidly is important, so I will expect such behavior of you in this class. Being honest and not cutting corners means doing your own work on assignments, not just copying from a friend or worse, cutting-and-pasting from the web/AI - that's plagiarism! It means not trying to give yourself an unfair or impermissible advantage on exams or quizzes through things like crib sheets, web helps, etc. Being honest obviously includes not giving a false or unfairly exaggerated reason to try to get a make-up or extension on a task. Maintaining standards means not doing someone else's work for them while letting them turn it in as their own. SRU's policy on academic integrity is at rockpride.sru.edu/policies/#search=integrity . The University expects that students will demonstrate their mastery of subject matter (in our case, skills, outcomes, and knowledge in our course) in an honorable and straightforward manner.