MAT 5531: Selected Topics in Differential Geometry

Dr. Sarah J. Greenwald

Contents

1.1 Catalog Description, Course Objectives, and Major Due Dates 1
1.2 Required Resources 2
1.3 Assignment Types, Grades, and Policies 2
1.4 Academic Affairs Policies 3
1.5 Course Communication, Where to Get Help, and Additional Policies 3
1.6 Instructor Bio 5

1.1 Catalog Description, Course Objectives, and Major Due Dates

Catalog Description: MAT 5530-5549 - Selected Topics (1-4). When Offered: On Demand

We consider the differential geometry of curves, surfaces, and spacetime, including theoretical and computational components, intrinsic and extrinsic viewpoints, and numerous applications. Prerequisite: linear algebra, multivariable calculus, differential equations, analysis, analytical physics. Graduate students who are enrolled in selected topics will attend the undergraduate course 4140. They will complete that work as well as extra graduate problems and assignments. For example, for the final project graduate students will have an additional component to research the literature (mathematics and/or physics and/or cs journals) and discuss some recent work, and if possible an open problem, that relates to the topic. See the individual assignments on the main webpage for details. Graduate students satisfy the undergraduate learning goals for the course as well as some additional goals:

Undergraduate Learning Goals

- To develop geometric skills and 3-D spatial visualization skills.
- To develop a greater appreciation for connections between various disciplines of mathematics, including geometry, linear algebra, complex analysis, and differential equations, along with an introduction to these subjects as they apply to differential geometry.
- To understand the importance of differential geometry in various scientific fields, including physics.
- To practice critical and creative thinking and to communicate effectively with your peers

(Additional) Graduate Learning Goals

- To build off of existing coursework in analysis, differential equations and analytical physics
- Research, review and interpret literature related to topics in differential geometry

Tentative Calendar of Topics and Major Activities
Details are on the course web page `http://cs.appstate.edu/~sjg/class/4140/s20.html`
Week 1: lines and curves
Homework 1: Review
Week 2: arc length and Frenet Frame
Week 3: Frenet formulas continued
Homework 2: Curves
Week 4: curvature and torsion
Homework 3: More Curves
Week 5: fundamental theorem of curves
Exam 1 on curves
Week 6: isoperimetric inequality, surfaces
Week 7: curvatures and geodesics
Homework 4: Intrinsic Geometry of Cones
Week 8: metrics and first and second fundamental form
Week 9: applications
Homework 5: Flat Donuts and Round Donuts
Week 10: surface area
Week 11: Gauss-Bonnet

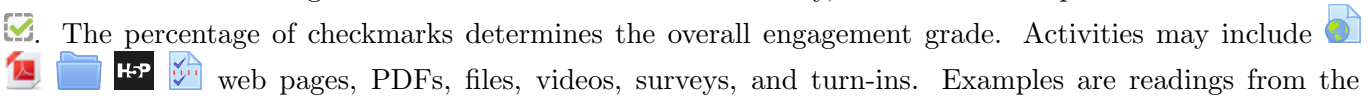
Homework 6: Research and Investigate a Surface
Week 12: Christoffel symbols
Exam 2 on surfaces
Week 13: spacetime and metric tensors
Week 14: applications to general relativity
Homework 7: Research and Investigate a Metric Form: Create a Video
Reading day: exam corrections
Final exam period: final project

1.2 Required Resources

- *Differential Geometry and Its Applications*, The Mathematical Association of America Edition in 2007, John Oprea, ISBN: 9780883857489, e-book: 9781614446088
- printouts of your Maple and other work
- access to a web browser and to library editions and Maple (on-campus access is sufficient as long as you have the time to work on campus while the labs are open). There are a number of advanced books on this topic in the e-book collection such as *Differential Geometry: Theory And Applications* by Daqian Li and Philippe Ciarlet, 2008, 9789812771469, 9789812771476.

1.3 Assignment Types, Grades, and Policies

- **Effective Class Engagement** 7.5%
  Attendance is required at ALL classes, and will form a portion of your grade. If you must be late to a class, or must leave early, then do still attend. You are also expected to take notes and contribute to discussions, activities, and questions in a meaningful way. Examples of engagement activities include Maple applets and paper folding activities. Asking or answering related and thought-provoking questions, coming up with creative ways of thinking about the material, and explaining the material to others are some examples of positive class engagement that will increase your grade. Appalachian's General Education Program prepares students to employ various modes of communication that can help communities reach consensus or respectful disagreement: successful communicators interact effectively with people of both similar and different experiences and values and in this course you will practice oral and written communication by interacting with your peers and me. Regardless of gender, political party, race, religion, sexuality, or more this is to be a welcoming environment, and so I want you to be sensitive and respectful to each other. Part of the welcoming environment is to keep an open mind as you engage in our class activities. Performing activities that detract from this welcoming environment or distract your neighbors or me will result in a lowered grade. If you expect to miss more than 10% of classes due to university sponsored activities then I advise you to drop the course. Any student who wants to obtain an "excused absence" must meet certain responsibilities, including providing official documentation and making up the work in advance, including homework as well as responses to in-class activities.

- **Effective ASULearn Engagement** 7.5%
  I mark ASULearn for a good faith effort rather than for accuracy, and indicate completion via a checkmark . The percentage of checkmarks determines the overall engagement grade. Activities may include  web pages, PDFs, files, videos, surveys, and turn-ins. Examples are readings from the book as well as the following short readings: *Curves* and *Surfaces*, both by Dogan Comez, myself and Jill Thomley, *How Flies Fly: Kappatau Space Curves* by Rudy Rucker, *How to Create Your Own Universe in Three Easy Steps* by Lawrence Brenton, and *Relativity* by David Brink. Checkmarks may be ones where you can manually mark the solid box activity as completed or are earned when you access an activity or receive a proficient grade by a deadline (until the relevant exam or portion of class). No lates allowed*.

- **Homework** 30%
  There are 7 homeworks over the course of the semester, which include problem sets as well as research projects that you will also share with your classmates. Your work must be turned in on or before the

due date at the beginning of class*. To accommodate issues that may arise, the lowest homework will automatically be dropped—save this for emergencies. If you have earned a passing grade of at least 60% for every homework (including the dropped one) then you will receive +1 added on to your final average.

- **Exams** 40% There are two exams designed to help you solidify and make connections. To encourage exams as a learning experience, accommodate for emergencies, and help solidify your knowledge, you can turn in revisions on one exam by reading day. Otherwise, no late tests allowed*.

- **Final Project** 15%
`http://cs.appstate.edu/~sjg/class/4140/fpideas.html` You must participate to pass the class*. Your presentation is in our assigned time during finals: Tuesday May 5, 11–1:30. As on `https://facultyhandbook.appstate.edu/sites/facultyhandbook.appstate.edu/files/faculty_handbook_2019.pdf` "an instructor may NOT change the date or time of an examination without permission of the departmental chair and dean... Permission is granted only in case of emergency."

* Accommodations in the determination of your final grade will be made for extenuating circumstances that are officially documented to prevent you from completing work early/on time.

The grading scale is: $A \geq 93; 90 \leq A- < 93; 87 \leq B+ < 90$...

1.4 Academic Affairs Policies

We adhere to the University-wide syllabus and policy statements:
`https://academicaffairs.appstate.edu/resources/syllabi-policy-and-statement-information`

1.5 Course Communication, Where to Get Help, and Additional Policies

- Office Hours and ASULearn: My office hours are in 326 on T/H 10:15–10:30, 12:30–1:45, and 3:15–3:30. I encourage you to talk to me often in class, office hours, and on the ASULearn forums. Any changes, extra additions or cancellations are announced in class, online, and/or on my door when possible. Sometimes, if no one comes to office hours, I go down the hall to the mailroom, photocopy machine, or to talk to another professor. If I am not in my office during office hours, you should walk down the hall to look for me, and interrupt to tell me that you are there. I am always around and happy to help you during office hours unless otherwise posted. You do not need to make an appointment to use office hours—just drop by! I am happy to answer your questions, go over material you are not feeling comfortable with, or help you work on assignments. If someone else is in my office hours, join us—we'll take turns for questions. I strongly prefer that you use office hours, but if you can't make them, message me on the ASULearn private forum, which I'll try to answer at least once a day. ASULearn is also where you can view your progress in the course.

- Communicating about work for missed classes: If there is some reason you must miss a class, then keep me informed on the ASULearn private forum—need help from me forum—with any official documentation, and obtain homework and class activities from the web pages to turn in early or on time, if possible.

- Inclement weather: If the university cancels classes, check the class web pages for updated info, which may include plans for the missed class such as additional readings, problems, video meetings, Chat, and/or Forum sessions in ASULearn. Homework may still be due onto the private ASULearn forum.

The Conference Board of the Mathematical Sciences (CBMS) published a statement titled "Active Learning in Post-Secondary Mathematics Education" about the importance of "classroom practices that engage students in activities, such as reading, writing, discussion, or problem solving, that promote higher-order thinking" and our classroom is modeled after that. The purpose of engagement is to learn and practice course content and learning goals, and develop critical thinking and problem-solving skills. Making mistakes is integral to the learning process—the key is to try to continue to engage rather than give up—and this course is to be an environment in which you ask questions and offer good guesses. It is on purpose that there are problems that don't look exactly like what we did previously in order to provide you with rich settings to explore in order to learn deeply.

Asking questions, and explaining things to others, in or out of class, is one of the best ways to improve your understanding of the material and I am always happy to help.

I believe that you have the capability to succeed in this course. As per the University-wide Statement on Student Engagement with Courses you can expect to spend (on average) 2–3 hours outside of class for each hour in class on assignments and reviewing material. If you find that you are spending fewer hours, you can probably improve your understanding and grade by studying more. If you are (on average) spending more hours than these guidelines suggest, you may be working inefficiently; in that case, you should come see me.

Many activities are designed to be completed during class and you are responsible for all material and announcements, whether you are present or not. You are also responsible for announcements made on the web pages, so check them often.

I want you to be informed about your choices regarding what you tell me about certain types of sensitive information. In situations where students disclose experiencing an act of interpersonal violence to their instructor, faculty are required to report that to the campus Title IX Coordinator, who then reaches out to the student by email offering support services. I care about you and want you to get the resources you need. I'm happy to talk with you if you decide you want that, but please be aware that if instead you'd like to explore options with someone who can keep your information totally confidential, I highly recommend the Counseling Center at 828-262-3180. They offer walk-in hours as well as after-hours coverage: `http://counseling.appstate.edu`.

- Appalachian Cares is a place to find updates about matters of student health and safety. `http://appcares.appstate.edu/`.
- Any student who has difficulty affording groceries or accessing sufficient food to eat every day, or who lacks a safe and stable place to live, and believes this may affect their performance in the course, is urged to contact the Dean of Students, 324 Plemmons Student Union, for a list of resources and support. The ASU Food Pantry and Free Store is a free resource with pantry and personal care items, located in the Office of Sustainability on the bottom floor of East Hall.
- The library offers Research Advisory Program (RAP) sessions. `http://library.appstate.edu/gethelp/rap`
- The Learning Assistance Program provides core services including University Tutorial Services, Academic Strategy Instruction, As-U-R, ACCESS, Student Support Services, and Academic Services for Student Athletes/ `http://lap.appstate.edu/welcome-learning-assistance-program-1`
- AppSync is your one-stop connection to engagement and leadership opportunities at Appalachian State. `https://appsync.appstate.edu/`

Academic integrity is a fundamental part of the course, which includes meeting deadlines, regular communication, and giving proper reference where it is due. These are essential to course integrity. Feel free to talk to me or each other if you are stuck, but when writing up work, be sure to give acknowledgment where it is due. Submitting someone else's work as your own (PLAGIARISM) is a serious violation of the University's Academic Integrity Code, which defines: "Plagiarism includes, but is not limited to, borrowing, downloading, cutting and pasting, and paraphrasing without acknowledgement, including from online sources, or allowing an individual's academic work to be submitted as another's work."

Use of technology is allowed only when it is related to our class. Photos or video or audio recordings may not be taken in class without prior permission. Food and beverages are allowed as long as they aren't distracting, but e-cigs, chewing tobacco/spit cups and other products are not allowed.

In this course, you will be challenged with problems that you have never seen before. I do not expect you to be able to solve all the issues immediately. Instead, I want to see what you can do on your own. Out in the real world, this is important, since no matter what job you have, you will be expected to seek out information and answers to new topics you have not seen before. This may feel uncomfortable and frustrating. I understand this and want to help you through the process. It helps to remember that there are no mathematical dead-ends! Each time we get stuck, it teaches us something about the problem we are working on, and leads us to a deeper understanding of the mathematics. In the real world though, you are not expected to face your work alone. You will be allowed to talk to other people and you may even be expected to work with other people. In this class, you are also not expected to face your work alone. I am always happy to help you and will try to give you hints and direction to help you understand the material. At times though, to encourage the exploration process, I may

direct you to rethink a problem and to come back to discuss it with me again afterwards. This occurs when I believe that the struggle to understand is imperative for your deep understanding of the material.

1.6 Instructor Bio

I am a full Professor of Mathematics, and I am also an affiliate of Gender, Women's and Sexuality Studies (GWS), investigating the connections between mathematics and society. My PhD in Riemannian geometry is from the University of Pennsylvania. I am married to the bassist Joel Landsberg. In our spare time, we like to travel, hike and conduct genealogy research. In addition to my own personal genealogy, I like to give back to the broader community, and in this context, I am affiliated with ASU's center for Judaic, Holocaust and Peace Studies. Some of what I like about mathematics is also what I enjoy about genealogy—the sense of exploration, discovery and aha moments that come with lots of patience and effort.