Department of Geography and Geoinformation Science
College of Science
George Mason University

GGS 366: Spatial Computing

Spring 2026

About the Course

Time and Location	Online Asynchronous
Credits	3 Credit Hours
Prerequisites	None
Website	https://canvas.gmu.edu
GitHub	https://github.com/armitakar/GGS366_Spatial_Computing
Textbook	N/A

About Instructor

Instructor	Armita Kar (she/her)
Office Hours	By Appointment
Office Location	Exploratory Hall 2215 (Zoom)
Email	akar3@gmu.edu
Teaching Assistant	Ayda Zaroujtaghi (azaroujt@gmu.edu)

1 Course Overview

Spatial computing enables location-based data processing, visualization, and analysis within a digital computing environment to solve complex economic, environmental, and social problems. From individual users to large institutions, spatial computing techniques are adopted everywhere to promote efficient functioning of our urban systems. Our everyday movement and activities have become much simpler as we can now solve numerous spatial problems with our mobile phones, such as finding a nearby restaurant using Google Maps and sharing locations with friends and family. Beyond individual-level applications, researchers and practitioners extensively use spatial computing to enrich place-based knowledge gain and targeted decision-making toward pressing urban challenges related to mobility, housing, health, finance, climate, equity, and resilience.

Recognizing its widespread applications, the off-the-shelf spatial analytics software, such as ESRI ArcGIS Pro or QGIS, offers an intuitive and user-friendly spatial computing platform for a broad range of users. Yet, knowledge of core spatial computing concepts and their applications using Python Programming is imperative for spatial scientists as Python is the foundational scripting language for many popular GIS software. Being able to write and execute Python codes will allow spatial scientists to develop new algorithms and methods, as well as automate spatial problem-solving in time-efficient, reproducible, and scalable formats.

This class focuses on developing students' basic to intermediate spatial computing skills using Python. Students will learn the core concepts of spatial computing and applications using both basic functions and object-oriented approaches. The course is structured into two main parts:

1. **Introduction to basic Python and spatial analytics**: The first half of the course will introduce students to Python programming, covering basic syntax, operations, and their applications in processing and analyzing spatial data.

2. **Applied spatial computing addressing urban challenges**: In the second half, students will work on a class project, aiming to enhance their problem-solving and critical thinking abilities. In this project, students will work on a real-world urban problem of their choice, identify relevant datasets and spatial computing methods for analyzing the problem, and report their findings in written format.

No programming experience is expected, meaning the class will progress from an introductory to the intermediate programming stage.

1.1 Learning Outcomes

Upon successful completion of this course, students will be able to –

1. Understand the basics of computer programming (e.g., variables, functions, iteration etc.), as well as different design approaches (functional versus object-oriented), with relevance to the spatial sciences.
2. Master important programming applications (e.g., Google Colab) and key spatial computing packages (e.g., shapely, geopandas etc.).

3. Develop critical thinking skills for spatial computing uses, design approaches, and methodological choices.

1.2 Course format

The course format is online asynchronous; there are **no in-person meetings or scheduled instructor-led online sessions**. Yet, to maintain a steady learning pace, this course requires students to review video lecture contents and complete lab assignments on a weekly basis. **Class materials will be posted every Tuesday** through the course GitHub page. Each week's content will include video lectures on a specified topic, example codes, and relevant lab assignments.

2 Course Materials

There is no specific textbook for this course. All necessary class materials will be available on the course GitHub page. Should you require additional information to learn Python, many free and open resources exist. A few example sources are given below:

- Al Sweigart. (2020). Automate the Boring Stuff with Python
  - Automate the Boring Stuff with Python
- Dave Whipp (2023). *Geo-Python 2023*.
  - https://geo-python-site.readthedocs.io
- Michael Dorman (2023). *Introduction to Geospatial Programming with Python*.
  - https://geobgu.xyz/py/index.html
- Ujaval Gandhi (2024). *Python Foundation for Spatial Analysis*.
  - https://courses.spatialthoughts.com/python-foundation.html
- Official tutorial documentation published by Python software foundation:
  - The Python Tutorial — Python 3.12.1 documentation
- Rey, S., Arribas-Bel, D., & Wolf, L. J. (2023). *Geographic data science with Python*. CRC Press.
  - Online version: Home — Geographic Data Science with Python
- Grus, J. (2019). Data science from scratch: first principles with Python. O'Reilly Media.
  - Codes of this book are available here: joelgrus/data-science-from-scratch: code for Data Science From Scratch book (github.com)

You will need the following technical resources to complete the course assignments and project.

- **Computer access for using Google Colab**: This course will use Google Colab, a virtual notebook environment for writing and executing Python code, which can be run on any computer via a web browser. Regarding this, personal access to a computer with an operating system of Windows 10 or Mac OSX 10.13 or higher and a fast and reliable broadband connection (e.g., > 10-20 Mbps) can be beneficial but not mandatory. Alternatively, you may use the **GGS Computer lab** to complete assignments. Once registered for a GGS class, you can anytime access GGS Computer Lab, Exploratory Hall 2102, via your student ID. Please email at ggs@gmu.edu to report issues. You can also use the GMU Virtual Computing Lab (https://www.vcl.gmu.edu/).

  To quickly check/inspect any spatial processing, you may also use licensed GIS software, e.g., ESRI ArcGIS Pro, via lab computers or open-source software, e.g., QGIS, via your personal

computer. Please be aware that this is a coding-focused class that will use GIS software as a secondary tool. You should not expect or seek to use these tools primarily in this class.

- **Canvas**: This course will use Canvas to distribute large datasets and administer course activities, namely lab assignments, course project, and final exam.

- **GMU Email account and NetID**: You must use your GMU email account and NetID to access Canvas and lab computers.

3 Course Activities and Grading

The course has three main activities: 7 labs (49%), a course project (36%), and a final exam (15%).

Category		Total points	Assessment level	Percentage of total grade
Lab		245 (7 labs, 35 points each)	Individual	49%
Project proposal	**Project meeting**	30	Individual	6%
	Project proposal	50	Group	10%
	Final report	100	Individual	20%
Final exam		75	Individual	15%
Total		500		100%

3.1 Labs

This course has 7 labs administered via Canvas. Each lab involves hands-on coding exercises on the topics taught each Tuesday and is **due the following Tuesday at 11:59 PM**. Please correspond with Canvas to keep track of course activities and their due dates to ensure on-time submission.

Labs are designed to practice and sharpen your programming skills and gain firsthand experience exploring, visualizing, and analyzing geospatial data using Python. Your lab submissions will be assessed on both the correctness of your code, as well as your logical reasoning skills; in other words, how proficiently you approach a problem is equally important as finding the correct answer. Regarding this, the lab assignment may sometimes ask you to write pseudocode (a step-by-step description of an algorithm using plain English text) to test your comprehension of a given problem.

I will post the lab instructions on GitHub and supplementary datasets on Canvas. **Please use the Canvas discussion board to post any course or lab-related queries, as well as help your peers resolve the issues**. However, each student is responsible for completing the work independently and submitting their individual assignments. Each lab is worth 35 points, totaling 245 points. The labs will account for 49% of the total grade.

You may explore online resources, such as the official documentation of Python libraries, GitHub pages illustrating example applications, and Stack Overflow in solving their lab assignments. The use of

Generative AI tools, such as ChatGPT, is also permissible. However, you should only use them as supporting tools, providing suggestions for writing specific syntaxes or debugging errors. However, while using Generative AI tools, you should strictly follow the fundamental principles of the academic standards stated in Section 5.1. Directly copying codes from AI tools is strictly prohibited. In your code, comment out the citations when using the work of others, whether individual people, online content, or generative AI tools.

3.2 Project

The course project will involve using techniques taught throughout the semester but applied to a research topic of your choice. **Students will complete the project in groups, each consisting of 3-4 students.** Students are welcome to create their own groups. Otherwise, I will create project groups based on similarities in students' research interests.

Week 4 lectures will cover the detailed instructions regarding the class project. I will introduce you to the publicly available geospatial datasets, example research questions, and methods appropriate for the class project. You are welcome to choose/modify any of the example research projects or develop research questions that interest you. Following the project introduction, three main tasks will be due in the upcoming weeks:

- **Project meetings with the instructor:** Each group must schedule two online meetings with me, one on weeks 5/6 to discuss project ideas and another on weeks 12/13 to discuss project progress and any programming issues. The project meetings are worth 6% of the total grades. **Each team member will be graded individually** based on their attendance and participation during the project meeting. I will provide plenty of time slots for groups to pick a time that works for everyone on the team.
- **Project proposal:** This project proposal is due in week 7 and is worth 10% of the total grade. It should not be more than 1000 words and contain a problem statement, objectives, preliminary literature review, data and methods, expected outcomes, and references (excluded from the word count). **The project proposal will be graded as a group effort.** In addition to the project proposal, each group needs to submit a list stating the distributions of tasks among the team members, which will later be used to evaluate your contributions toward the final report.
- **Final report:** The final project is due on week 15 and is worth 20% of the total grade. Each group must submit the final codes and a project report of about 4000-6000 words. This report must follow a standard journal article format, containing sections on Introduction, Literature review, Data and Method, Results, Discussion, and Conclusion. In addition, each group needs to provide a title page stating author names and affiliations, abstract (<250 words), and references (excluded from the word count). The references should follow APA format (7th edition). You are encouraged to use referencing software such as Zotero or Endnote to automate the referencing system. **The final report will be individually graded based on the quality of the sections each student contributed**.

Please submit all project-related documents online through Canvas.

3.3 Final Exam

The exam will consist of multiple-choice questions on the basics of spatial computing and will be worth 15% of the total grade. The exams (mid-terms and final) will be closed-book and administered via Canvas.

3.4 Grading Scale

Grades	Percentage Required	Grades	Percentage Required
A+	96 to 100	**C+**	76 to 79.9
A	93 to 95.9	**C**	73 to 75.9
A-	90 to 92.9	**C-**	70 to 72.9
B+	86 to 89.9	**D**	60 to 69.9
B	83 to 85.9	**F**	<60
B-	80 to 82.9		

3.5 Course Outline and Tentative Schedule

*** The syllabus is subject to change; please review Canvas for the most up-to-date version ***

Week	Date	Topic	Assignment due
Week 1	20-Jan	Course overview and Introduction to Google Colab environment	
Week 2	27-Jan	Basic Python concepts: Variables, data types, and functions	Student Introductions (Ungraded)
Week 3	3-Feb	Data structures - List, tuple, dictionary, and set	Lab 1
Week 4	10-Feb	Control flow operators: Conditional statements and iterations **Project Introduction**	Lab 2
Week 5	17-Feb	Tabular and spatial data wrangling with pandas and geopandas **Project proposal meeting**	Lab 3
Week 6	24-Feb	Spatial operations and query with shapely and geopandas **Project proposal meeting**	Lab 4
Week 7	3-Mar	Data visualizations and mapping	**Project proposal**
	10-Mar	**Spring Recess (no lectures)**	
Week 8	17-Mar	Point pattern analysis with PySal	Lab 5
Week 9	24-Mar	Network analysis with NetworkX and OSMnx	Lab 6
Week 10	31-Mar	Intro to object-oriented programming (part 1).	Lab 7
Week 11	7-Apr	Intro to object-oriented programming (part 2).	
Week 12	14-Apr	**Project progress meeting**	
Week 13	21-Apr	**Project progress meeting**	
Week 14	1-May		**Final Project submission**
	6-May	**Final Exam**	

4 Student Engagement Policies

4.1 Problem-Solving

It is inevitable that problems will arise, especially when working with Python code. Therefore, it is essential that students follow a set of key procedures when dealing with any coding issues encountered. These are as follows:

- Copy and paste any error messages into a search engine (e.g., Google). Someone else will already have had the same problem, so investigate how other researchers solved similar issues.
- Explore Stack Overflow questions and answers. When other programmers have been stuck, they post them publicly on Stack Overflow, asking for answers, making this a great resource.
- If you still cannot solve the problem, either post a public question on Stack Overflow or on the Canvas discussion page.

4.2 Make-up assignments

I will provide reasonable accommodations for university-approved excused absences, such as religious observations and university activities. To receive approval, please notify me with documentation within the first two weeks of the semester.

I will also make an exception for personal emergencies, such as illness and family crises. To request an exception, please email me as soon as the situation arises. Please note that you are responsible for following up with me to discuss potential make-up work options (e.g., time extensions for labs with no penalties).

4.3 Late Lab Assignment

The due dates and times for each lab are posted on Canvas. A submission will be considered late if marked as late on Canvas. The following penalties apply to late submissions:

- A 10% grade reduction if the assignment is submitted within a week of the due date.
- A 25% grade reduction if the assignment is submitted within two weeks of the due date.
- Submissions over two weeks late will receive 0 points unless a time extension has been granted for exceptional circumstances, as discussed above.

You should be proactive in completing your lab assignments early to avoid last-minute technical issues such as "didn't have internet," "computer system error," or "Canvas was giving me an error." No time extensions will be granted for such cases. You may choose to submit partial work on time or submit late and receive a grade with late penalties.

4.4 Proper Address and Pronoun Use

I welcome you to share your chosen name and gender pronouns via the Mason-provided website: https://registrar.gmu.edu/updating-chosen-name-pronouns/. These changes will appear in the Canvas class sites and other places, helping me to best address you.

My pronouns are she/her/hers. I appreciate you addressing me by my first name.

4.5 Contacting Me

Please feel free to email me for any queries. I will do my best to respond to emails received on weekdays within 24 hours and weekend emails within 48 hours. You may send a gentle reminder if you do not receive a response within this timeframe. If you need further assistance, you can also schedule an appointment to meet me in person or via Zoom during my office hours. **Please use your GMU email account for any correspondence related to this class.**

That said, **if you have any general questions about lab assignments, please post them on the Canvas discussion board**. This collaborative approach helps everyone by enabling group problem-solving. Peers who have encountered similar issues can respond quickly, and future students facing the same challenges can benefit from the shared discussion.

5 University Policies and Support Services

5.1 Academic Standards

Academic Standards exist to promote authentic scholarship, support the institution's goal of maintaining high standards of academic excellence, and encourage continued ethical behavior of faculty and students to cultivate an educational community which values integrity and produces graduates who carry this commitment forward into professional practice.

As members of the George Mason University community, we are committed to fostering an environment of trust, respect, and scholarly excellence. Our academic standards are the foundation of this commitment, guiding our behavior and interactions within this academic community. The practices for implementing these standards adapt to modern practices, disciplinary contexts, and technological advancements. Our standards are embodied in our courses, policies, and scholarship, and are upheld in the following principles:

- **Honesty:** Providing accurate information in all academic endeavors, including communications, assignments, and examinations.
- **Acknowledgement:** Giving proper credit for all contributions to one's work. This involves the use of accurate citations and references for any ideas, words, or materials created by others in the style appropriate to the discipline. It also includes acknowledging shared authorship in group projects, co-authored pieces, and project reports.
- **Uniqueness of Work:** Ensuring that all submitted work is the result of one's own effort and is original, including free from self-plagiarism. This principle extends to written assignments, code, presentations, exams, and all other forms of academic work.

Violations of these standards—including but not limited to plagiarism, fabrication, and cheating—are taken seriously and will be addressed in accordance with university policies. The process for reporting, investigating, and adjudicating violations is outlined in the university's procedures. Consequences of violations may include academic sanctions, disciplinary actions, and other measures necessary to uphold the integrity of our academic community.

The principles outlined in these academic standards reflect our collective commitment to upholding the highest standards of honesty, acknowledgement, and uniqueness of work. By adhering to these principles, we ensure the continued excellence and integrity of George Mason University's academic community.

Student responsibility: Students are responsible for understanding how these general expectations regarding academic standards apply to each course, assignment, or exam they participate in; students should ask their instructor for clarification on any aspect that is not clear to them.

5.2 Accommodations for Students with Disabilities

Disability Services at George Mason University is committed to upholding the letter and spirit of the laws that ensure equal treatment of people with disabilities. Under the administration of University Life, Disability Services implements and coordinates reasonable accommodations and disability-related services that afford equal access to university programs and activities. Students can begin the registration process with Disability Services at any time during their enrollment at George Mason University. If you are seeking accommodations, please visit https://ds.gmu.edu/ for detailed information about the Disability Services registration process. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email: ods@gmu.edu. Phone: (703) 993-2474.

Student responsibility: Students are responsible for registering with Disability Services and communicating about their approved accommodations with their instructor *in advance* of any relevant class meeting, assignment, or exam.

5.3 FERPA and Use of GMU Email Addresses for Course Communication

The Family Educational Rights and Privacy Act (FERPA) governs the disclosure of education records for eligible students and is an essential aspect of any course. **Students must use their GMU email account** to receive important University information, including communications related to this class. Instructors will not respond to messages sent from or send messages regarding course content to a non-GMU email address.

Student responsibility: Students are responsible for checking their GMU email regularly for course-related information, and/or ensuring that GMU email messages are forwarded to an account they do check.

5.4 Title IX Resources and Required Reporting

As a part of George Mason University's commitment to providing a safe and non-discriminatory learning, living, and working environment for all members of the University community, the University does not discriminate on the basis of sex or gender in any of its education or employment programs and activities. Accordingly, **all non-confidential employees, including your faculty member, have a legal requirement to report to the Title IX Coordinator, all relevant details obtained directly or indirectly about any incident of Prohibited Conduct** (such as sexual harassment, sexual assault, gender-based stalking, dating/domestic violence). Upon notifying the Title IX Coordinator of possible Prohibited Conduct, the Title IX Coordinator will assess the report and determine if outreach is required. If outreach is required, the individual the report is about (the "Complainant") will receive a communication, likely in the form of an email, offering that person the option to meet with a representative of the Title IX office.

For more information about non-confidential employees, resources, and Prohibited Conduct, please see University Policy 1202: Sexual and Gender-Based Misconduct and Other Forms of Interpersonal Violence.

Questions regarding Title IX can be directed to the Title IX Coordinator via email to TitleIX@gmu.edu, by phone at 703-993-8730, or in person on the Fairfax campus in Aquia 373.

Student opportunity: If you prefer to speak to someone **confidentially**, please contact one of Mason's confidential employees in Student Support and Advocacy (SSAC), Counseling and Psychological Services (CAPS), Student Health Services (SHS), and/or the Office of the University Ombudsperson.

5.5 AI use policy

Students must complete all course labs and assignments independently, without relying on generative AI tools. All data processing, map visualizations, and written responses must be the students' own work. The use of Generative AI tools, such as ChatGPT, Gemini, and Claude, is permissible for brainstorming, idea generation, and grammar and sentence refinement, but all implementations must be their own. Note that, while using Generative AI tools, you should strictly follow the fundamental principles of the academic standards stated in Section 5.1. Directly producing your answers from GenAI (e.g., directly generating your lab responses, models, and visualizations with GenAI) is strictly prohibited. At the end of each lab, please include a note citing the capacity in which you have used generative AI tools or any other online content.

Students should also recognize both the benefits and limitations of AI in learning and research. While AI can provide useful suggestions, it is not always accurate or reliable. Students are expected to critically evaluate AI-generated knowledge and rely primarily on the course textbook and other assigned materials. Violations of this policy will be considered academic misconduct. If you have any questions about whether a specific use of AI is permitted, please ask for clarification in advance.

5.6 University-wide Closures and Class Cancellations/Delays

There may be times during the semester in which George Mason University announces university-wide closures or delays. Should inclement weather or another emergency force Mason to close, causing our class to cancel meeting times, we will not meet. Check the Mason website and our own Canvas site for updates. Other cancellations or delays to class will be announced via canvas by your professor. In the event that this course has missed meeting times, the course schedule, assignment deadlines, and other course alterations will be decided upon and announced via canvas and email by the professor. You are expected to stay abreast of any changes.