GEOG 5222: GIS Programming and Algorithms

The Ohio State University
Autumn 2025

Course URL: http://carmen.osu.edu
Time: Tuesday and Thursday, 2:20 - 3:40 PM
Location: Derby Hall 135

Instructors
Prof. Ningchuan Xiao | xiao.37@osu.edu
Ms. Ruixuan Ding | ding.796@buckeyemail.osu.edu

Office hours

Day	Room	Time and zoom link	Instructor
Monday	1070 DB	1 - 2 PM	Ms. Ding
Tuesday	1160 DB	4 - 5 PM	Dr. Xiao
Wednesday	1070 DB	10 - 11 AM	Ms. Ding
Thursday	1160 DB	4 - 5 PM	Dr. Xiao

This class is about coding.

More specifically, we learn how to program a computer to handle spatial data in this class. It is obvious, one may argue, that today's software are often quite easy to use and they are also powerful. So why should we do coding? In his book *The Mythical Man-month*, Frederick P. Brooks, Jr. talked about the reward of coding as the sheer joy of making things. Others agreed. In a 1984 New York Times piece, Erik Sandberg-Diment gave three reasons of programming: "First, it allows you to develop software that is not available commercially, and in some cases it lets you customize purchased software to serve your specific needs better. Second, programming can be fun. If you enjoy working on puzzles, programming may well turn out to be more pleasurable than solving The Times crossword puzzle or Dr. Crypton's mind-bending puzzle page in Science Digest. Third, there is the intellectual exercise, the honing of logic skills and learning to learn, stressed by pedagogues as a perfect reason to have computers available in schools for pupils from kindergarten age on up." In a blog at Invent with Python, Al Sweigart pointed out that "Programming transforms your computer from a home appliance to a power tool." It is apparent that writing computer code is becoming an essential part of life. As Steve Jobs once put it, "everybody in this country should learn to program a computer...because it teaches you how to think."

In this class, we aim to help students gain freedom in dealing with spatial data though programming. After completing this class, students will develop understanding on how spatial data works and how to write their own code to handle the data, instead of relying on existing (especially commercial) software packages. We use the powerful and very popular (see PYPL or TIOBE) Python programming language in this class. We start from the basics of Python. About half way through the semester, we should have developed sufficient knowledge about programming with Python and will start to use it on spatial datasets. Most of the materials do not rely on existing software packages, which will provide an intuitive way of understanding spatial data and spatial data processing. By the end of the semester, students should understand the fundamental considerations of computational issues in spatial data processing and should be able to write Python code to complete various tasks of using spatial data.

Course learning outcomes

By the end of this course, students should be able to:

- Understand fundamental constructs and styles of programming using Python
- Write Python programs to conduct basic data processing and visualization
- Develop and test Python programs to process and visualize spatial data
- Develop and test Python programs for basic geometric processing
- Understand basic spatial indexing methods for point data sets
- Understand the basics of computational issues such as time complexity and indexing

Course materials

Two textbooks are required for this class:

- Allen B. Downey. 2024. **Think Python: How to Think Like a Computer Scientist**. 3rd Edition. Sebastopol, CA: O'Reilly Media.
- Ningchuan Xiao. 2016. **GIS Algorithms**. London, UK: SAGE Publications.

The Think Python book also has an online version at the author's github site: https://allendowney.github.io/ThinkPython/. This site has everything we need from this book: the content and code that can actually run because the book is presented in a Jupyter notebook format. We will use Jupyter notebooks until mid-semester, but by all means this web site should be a good option.

A GitHub site repository at http://github.com/gisalgs will be used intensively for more than a half of the class. We will only access this repository through a web browser. This is a public website and everyone can access. A detailed accessibility statement of GitHub can be found at https://government.github.com/accessibility. The privacy statement of GitHub can be found at https://help.github.com/en/github/site-policy/github-privacy-statement.

Tutorials and lecture notes will be made available through the course schedule page on Carmen. There are also numerous useful online sources for learning Python. Al Sweigart maintains a web site for his book at https://automatetheboringstuff.com. Also, The Hitchhiker's Guide to Python! (https://docs.python-guide.org) has information that can be extremely practical for many beginners. The official Python Tutorial (https://docs.python.org/3/tutorial) is a good place to find the details on most of the topics in Python coding (make sure to choose the right version on top of the page).

Coding can be fun. But learning a new programming language is like learning how to ride a bike or how to swim because they share some common traits:

- It takes time
- It is daunting
- It gets easier
- It takes (a lot of) hands-on

Schedule

The overall course contents are divided into a few major topics:

Weeks 1-5: Python programming language
Weeks 6-10: Geometric algorithms
Weeks 11-15: Spatial indexing
Weeks 15-16: Other topics

A detailed schedule can be found on the course page on Carmen. Students should check this page frequently as it will be updated whenever new materials are made available. Important notes regarding the course will also be posted on the home page.

Videos

Each class will be video taped. In addition, I also make various small videos explaining some special topics. All these videos will be posted on carmen either at the time the topics are posted or soon after the class. Please check the carmen page frequently for the availability of the videos.

Course technology

Necessary equipment

- Computer: current Mac (OS X) or PC (Windows 7+) with high-speed internet connection

Optional equipment (for zoom meetings when necessary)

- Webcam: built-in or external webcam, fully installed
- Microphone: built-in laptop or tablet mic or external microphone

Required software

- Python. We will use Python through out this class. To install Python on your computer, please download it from https://www.python.org/.
- Jupyter notebook. Starting week 9, we will use Google Colab to run Python code in Jupyter notebooks. This will require a Google account and a web browser.

Other course technology

For help with your password, university e-mail, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at https://ocio.osu.edu/help/hoursLinks to an external site., and support for urgent issues is available 24x7.

- Self-Service and Chat support: http://ocio.osu.edu/selfserviceLinks to an external site.
- Phone: 614-688-HELP (4357)
- Email: 8help@osu.edu
- TDD: 614-688-8743

Grading and Assignments

The following is a breakdown of the weights (in percent) for each category of the assignments.

Assignment category	Weight
Exercises	25
Case studies	10
Homework	15
Before you go...quizzes	10
Quizzes	20
Final projects	20
Total	100

Course organization and assignment information

Course contents are organized into modules. A typical module is designed for 5 instructional days (weekends and holidays not included), includes two meets. I will try to align modules

with calendar weeks. There are weeks that only have one instructional day for this class and I will typically use them for case studies when we dive deeper into more complex problem solving using Python. See the detailed schedule on Carmen for the specific tasks.

- **Exercises.** There are some relatively small questions associated with each module or weekly topic. These exercises are typically due in a week.
- **Case studies.** There are a few case studies throughout the semester. These are special topics that are highly related to what we discuss in this class. The actual topics used will vary from year to year. These topics can be intensive and I will walk through the theories and coding. Some case studies may also include questions extended from the demonstrations. Students will need to closely follow the demonstrated during class and complete the coding in a week.
- **Homework.** For each major topic on the course schedule, there will be a homework assignment with more in-depth questions. These questions typically require more intensive coding efforts and students have about two weeks to finish.
- **Before you go...quizzes.** There is an online and open-book quiz at the end of a module. The questions are related to the topics in the current module, but may also be cumulative. This quiz is timed. These are relatively small questions. Each student has two attempts and the highest score will be used.
- **Quizzes.** An online quiz will be given after we finish a major topic. These are open-book quizzes that will require students to write code to answer. These quizzes are intensive coding exercises that require students to finish in fixed amount of time. Each quiz will be open for a week and students can start the quiz anytime during that week.
- **Final projects.** A list of guided questions will be provided in the middle of the semester and each student will choose to answer one of these questions. The questions will be based on the topics covered in the semester. Only sufficient information will be provided, which means I will not provide all the implementation details for the questions and students must find solutions by themselves. There will also be open questions that give students a lot of freedom to choose their own project. The open questions will require a short proposal from the students.

Grading scale

Grades will not be rounded up. THe following scale is used to assign the final grade for this class.

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+

73–76.9: C
70 –72.9: C-
67 –69.9: D+
60 –66.9: D
Below 60: E

Faculty feedback and response time

The following list outlines the intended availability of the instruction team throughout the course. (Remember that you can call 614-688-HELP at any time if you have a technical problem.)

Grading and feedback For the exercises, students should be able to see the grade and feedback in a week after the due dates. For large tasks such as a homework assignment, the time frame to expect feedback is generally up to 2 weeks.

E-mail E-mails will be replied within 48 hours, and we aim for 24 hours during school days.

Office Hours In addition to the office hours listed in the syllabus, students may request other times to meet with the instruction team. Please give at least 24 hours notification and it will only be available during school days.

Course Policies

Do your own work. Collaboration is healthy and often necessary, but each student should definitely finish the work individually. Please see below for more information about academic misconduct. This policy also applies to the use of generative AI such as ChaptGPT. We will treat these as tools that can help us learn, but they are not going to replace us writing the code. There will be numerous situations in this class when we need to explain why the code works, which will only come from a natural understanding of programming.

Late assignments. Late submissions may be accepted up to a week past the due date. Each day after the due date will incur a 10% penalty. The total penalty will be up to 50%. Five to seven days late will only receive 50% credit of the grade you would have received if it was submitted on time. If you contact me ahead of time for deadline adjustments you will not incur any penalty. Please note this may not apply to every assignment. The final project, for example, has a firm deadline that cannot be changed. Please refer to Carmen for due dates.

Due date and make-ups. Due dates for all assignments will be clearly stated on Carmen. If you need any extensions, you must ask for it **prior to** the due date. Extensions will not be granted if requested after the due date. This applies to all assignments. For a quiz, the due date is the start of the class when the quiz is scheduled. Make-up quiz will only be given to those who request before the quiz starts.

Deliverables. All deliverables must be submitted on Carmen as specified in the assignment instructions. There will be absolutely **no email submissions**. Email submissions of work for this class will not be accepted and will not be acknowledged.

Communication. The only official way to communicate with the TA and myself is through our OSU email addresses as listed on the top of the syllabus. We cannot guarantee that we will reply messages through any other methods. We normally will reply emails in a instructional day.

Other Policies

Accessibility accommodations for students with disabilities

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.eduLinks to an external site.; 098 Baker Hall, 113 W. 12th Avenue.

Academic integrity

- Written assignments: Your written assignment, including discussion posts, should be your own original work. In formal assignments, you should follow a style guide such as The Chicago Manual of Style 17th edition to cite the ideas and words of your research sources.
- Reusing past work: In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you've explored in previous courses, please discuss the situation with me.
- Falsifying research or results: All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.
- Collaboration and informal peer-review: While study groups and peer-review of major written projects is encouraged, remember that comparing answers on a quiz or assignment is not permitted. If you're unsure about a particular situation, you should ask ahead of time.

The following is a list of other useful sources of information on academic misconduct and academic integrity:

- The Committee on Academic Misconduct web pages: COAM Home

- Ten Suggestions for Preserving Academic Integrity
- Eight Cardinal Rules of Academic Integrity
- How to Avoid Plagiarism

Ohio State's academic integrity policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/.

Copyright disclaimer

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Weather or other short-term closing

Should in-person classes be canceled, I will notify you as to which alternative methods of teaching will be offered to ensure continuity of instruction for this class. Communication will be via email, and in-class or Carmen announcements.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.eduLinks to an external site. or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu.

Accessibility of course technology

This online course requires use of Carmen (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations with your instructor.

- Carmen (Canvas) accessibility
- Streaming audio and video

- Synchronous course tools

Religious accommodations

It is Ohio State's policy to reasonably accommodate the sincerely held religious beliefs and practices of all students. The policy permits a student to be absent for up to three days each academic semester for reasons of faith or religious or spiritual belief.

Students planning to use religious beliefs or practices accommodations for course requirements must inform the instructor in writing no later than 14 days after the course begins. The instructor is then responsible for scheduling an alternative time and date for the course requirement, which may be before or after the original time and date of the course requirement. These alternative accommodations will remain confidential. It is the student's responsibility to ensure that all course assignments are completed.

Your mental health!

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.eduLinks to an external site. or calling 614- 292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available through the 24/7 National Suicide Prevention Hotline at 1-800-273- TALK or at suicidepreventionlifeline.org