

ESCI 5980: Computational Methods in Earth Science

Class meetings: MW 4–5:15 in Pillsbury Hall 209

Instructor

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This syllabus is subject to change based on the rate of progress of the class.

Course Description: Introduction to Python programming. Data reading, writing, analysis, processing, and visualization. Model development and finite difference methods. Final project of students choice that integrates skills gained during the course.

Prerequisite(s): Calculus recommended.

Credit Hours: 3

Text(s):

- *Think Python: How to Think Like a Computer Scientist*: PDF and HTML available at <http://www.greenteapress.com/thinkpython/>

Grade Distribution:

Mid-term projects and exercises	55%
Final project	40%
Class participation and teamwork	5%

Note that this grade distribution *may change slightly* if the distribution of effort in different parts of the course changes from what I expect.

Assignments:

Unless otherwise notified, all assignments will be due **one week** from the date on which they are assigned. If this date falls on a weekend, then they are due the first weekday after one week passes. After one week, late work will be worth half credit. This is necessary to ensure that I am able to return assignments to students in a timely manner, and to ensure that you keep up with course material. Of course, reasonable exceptions to these penalties and deadlines will be accepted (e.g., family or medical emergency), with arrangements for late work designed to accommodate these real-life events without causing undue stress (see below). Late or missed work due to reasons that the students knew about beforehand will not be accepted unless arrangements are made before the assignment is due; the definition of “beforehand” can be stretched for some circumstances (found out you broke your leg shortly before class) and not in others (scheduled absence due to a normal event). In general, I will accept most reasonable requests for extra time on assignments, provided the request is made at least 24 hours before the assignment is due, but reserve the right to use my judgment.

Readings:

Readings in the textbook will supplement your learning in class, but there will not be a 1:1 overlap

between readings and lectures. Sometimes they will be close to one another, and sometimes they will diverge but be complementary.

Course Schedule:

Week	Content
Weeks 1–4	<p>Introduction to Python programming and general programming concepts and implementation</p> <ul style="list-style-type: none"> • Commands in Python • Imperative and object-oriented programming • Software architecture and (re)usability
Weeks 5–8	<p>Data sets</p> <ul style="list-style-type: none"> • Familiarity with a range of data formats common across Earth, atmospheric, and oceanic sciences <ul style="list-style-type: none"> – Text files (ASCII) – binary data files – Spreadsheets – NetCDF – GIS data (raster and vector) – Remotely sensed data products – Government-collected data sets in standard formats (e.g., stream gauge data) • Data analysis <ul style="list-style-type: none"> – Remotely-sensed imagery to data products (e.g., NDVI, surface temperature) – Interpolation – Time-series and spectral analysis – Building automated tools to analyze well-formatted input data • Data visualization <ul style="list-style-type: none"> – Plotting tools (Matplotlib) – Specialized visualizers (e.g., Paraview, Panoply) – Map projection and plotting tools (e.g., Cartopy) • GIS applications, as time allows

Weeks 9–12	<p>Models</p> <ul style="list-style-type: none"> • Introduction to types of numerical models • Differential equations review/preview: simple analytical solutions, Taylor series approximations, and numerical solutions • Matrix algebra to solve systems of differential equations: applying the finite difference method <ul style="list-style-type: none"> – Discretizing equations – Numerical stability, numerical diffusion – Basic Euler forward – Banded matrix methods to solve equations – Sparsity, memory management – Implicit solution methods
Weeks 13–	<p>Final projects</p> <ul style="list-style-type: none"> • Build software that will assist you in a topic of your choosing (ideally related to your research) • Learn how to use version-control software and appropriate licensing for collaborative work • Integration of data and models is encouraged • Present results at the end of the semester

University of Minnesota Course Policies (Including small modifications for this class)

Student Conduct Code

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf.

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom

We will be using computers in the class, and you are expected to use them for course work.

Scholastic Dishonesty

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf) If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see: <http://policy.umn.edu/education/instructorresp>.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: <http://www1.umn.edu/oscai/integrity/student/index.html>. If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

Makeup Work for Legitimate Absences

Students will not be penalized for absence or late work during the semester due to unavoidable or legitimate circumstances, provided that the instructors are notified prior to the absence (if possible) and a signed note explaining the absence is provided. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. Arrangements for delayed work must also be made in advance, with the exception of unanticipated emergency situations, in which the instructor may, at their discretion, excuse absence(s) and/or late and/or missing assignments.

Students must notify their instructors of circumstances leading to a request for makeup work as soon as possible and provide information to explain the absence. Some situations will be sufficiently urgent that arrangements for makeup work cannot be made prior to the date of an absence. In such cases, arrangements should be made as soon as possible following the students return.

For additional information, please see: <http://policy.umn.edu/education/makeupwork>.

Office hours

Faculty and TA office hours will be to benefit learning with the addition of the possibility of one-on-one and small-group learning time. Students are encouraged to attend office hours to supplement their learning. However, office hours are not intended as a replacement for class: students who miss a class period will not receive a makeup lesson on this material during office hours. They will instead be directed to the online course materials, the readings, and their student colleagues' notes.

Appropriate Student Use of Class Notes and Course Materials

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substan-

tially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: <http://policy.umn.edu/education/studentresp>.

Grading and Transcripts

The University utilizes plus and minus grading on a 4.000 cumulative grade point scale in accordance with the following:

A	4.000	Represents achievement that is outstanding relative to the level necessary to meet course requirements
A-	3.667	
B+	3.333	
B	3.000	
B-	2.667	Represents achievement that is significantly above the level necessary to meet course requirements
C+	2.333	
C	2.000	
C-	1.667	
D+	1.333	Represents achievement that meets the course requirements in every respect
D	1.000	
S	–	Represents achievement that is worthy of credit even though it fails to meet fully the course requirements
		Represents achievement that is satisfactory, which is equivalent to a C- or better.

For additional information, please refer to: <http://policy.umn.edu/education/gradingtranscripts>.

Sexual Harassment

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy: <http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf>.

Equity, Diversity, Equal Opportunity, and Affirmative Action The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf.

Disability Accommodations

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact Disability Resource Center at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

If you are registered with Disability Resource Center and have a current letter requesting rea-

sonable accommodations, please contact your instructor as early in the semester as possible to discuss how the accommodations will be applied in the course.

For more information, please see the Disability Resource Center website, <https://diversity.umn.edu/disability/>.

Mental Health and Stress Management

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 and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: <http://www.mentalhealth.umn.edu>.

Academic Freedom and Responsibility Academic freedom is a cornerstone of the University. Within the scope and content of the course as defined by the instructor, it includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.*

Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help. Contact the instructor, the Department Chair, your adviser, the associate dean of the college, or the Vice Provost for Faculty and Academic Affairs in the Office of the Provost. [Customize with names and contact information as appropriate for the course/college/campus.]

* Language adapted from the American Association of University Professors "Joint Statement on Rights and Freedoms of Students".