EAS 4690/6690: Glacier Dynamics Syllabus

[3 credit hours]

[M/W 9:30-10:45am]

Instructor Information

Instructor	Email	Drop-in Hours & Location
Prof. Alexander Robel	robel@eas.gatech.edu	TBD, Ford ES&T 2252

General Course Information

Description

This course covers the fundamentals of glacier and ice-sheet dynamics and their application to problems in sea level, paleoclimate, and planetary science. Course content includes glacier observations, mass balance, the material properties and rheology of ice, the basic equations of ice- sheet and -shelf flow, basal processes, the stability and history of ice sheets. This course is targeted at graduate students in climate, geophysics and planetary sciences, but is also appropriate for any undergraduate student with sufficient interest and prerequisite understanding of undergraduate-level mathematics and Earth sciences.

Pre- &/or Co-Requisites

Undergraduate: (1) CS 1301 or CS 1371, (2) MATH 2552 (pre-requisite with concurrency)

Graduate: None

Other Recommend Skills: An undergraduate-level understanding of calculus and differential equations. Some introductory ability with simple programming (MATLAB or Python preferably).

Course Goals and Learning Outcomes

At the end of this course, students should be able to read literature in glaciology and have an understanding of the important ideas in the field. Students should have an understanding of the most relevant observations constraining our understanding of ice sheet processes and be able to perform simple analysis of glaciological data sets. Students should understand the equations which are used in ice sheet models and interpret output from complex ice sheet models.

Course Requirements & Grading

Problem sets are approximately every 2 weeks (60%), final project (30%), final project talk+participation (10%). Problem sets are meant to challenge you to think like a scientist about a problem that you have never seen before using some math, simple coding, or data analysis. Though figuring out an approach and solution to these problems may take some time, if you feel stuck or think the problem is incorrectly posed, please send me an e-mail or see one of the instructors in office hours.

UG/G Section Differentiation: Expectations for the course assessments are differentiated between those enrolled in the undergraduate (4690) and graduate (6690) sections. In problem sets, more challenging problems will be required for 6690 and offered as extra credit for the 4690. For example, problems required advanced data analysis or programming abilities beyond the standard EAS undergraduate curriculum will not be required for 4690. 6690 students will be expected write a 8-15 page final report, in contrast to 6-10 pages for 4690 students. Final projects for 6690 students will be expected to include original analysis of a dataset or model using methods from the course, compared to 4690 students for whom reproduction of a prior result without available analysis code is sufficient for final projects.

Assignment	Date	Weight (Percentage, points, etc)
Problem Sets	Bi-Weekly	60% (total)
Final Group Project	December XX	40%

Description of Graded Components

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Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

Course Text

There is no single textbook for our class that you need to purchase. This is a non-exhaustive list of various interesting and useful books that you may need to consult occasionally.

- K.M. Cuffey and W.S.B Paterson, The Physics of Glaciers, B-H, 4th ed., 2010.
- C.J. van der Veen, Fundamentals of Glacier Dynamics, CRC Press, 2nd ed., 2013.
- R. LeB. Hooke, Principles of Glacier Mechanics, Cambridge U Press, 2nd ed., 2005.

Downloadable ebook versions of Cuffey (https://www.sciencedirect.com/book/9780080240053/the-physics-of-glaciers) and van der Veen (https://www.taylorfrancis.com/books/9781439835678) are available with GT library access

Course Policies, Expectations, & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review Georgia Tech's Honor Code and the student Code of Conduct.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and Participation

Attendance and participation are not part of the course grade. Therefore, if you are sick, please do not come into class. Lecture material will all be posted on canvas. That being said, the lectures will only be offered in person and since the course is not based closely on existing textbooks, students should attend lectures and other course activities to get the most out of the learning experience.

Collaboration, Group Work, and Use of Generative AI

For individual assignments: Working collaboratively with classmates to figure out the right approach to a problem is acceptable - but you may not copy code or solutions from one another. If you talked to or worked with someone else, please indicate so by writing "worked with:" at the top of pg. 1 of your submitted solutions.

For group assignments: In group projects, collaboratively make a plan at the beginning for which parts of the project will be done by which group members or collaboratively by multiple group members. Students may express concerns to the instructors if all group members are not contributing previously agreed-upon work. In general all group members will receive the same grade for a project, but instructors reserve the right to differentiate grades within a group if it is clear that not all members have contributed fairly to the final product.

AI Policy: AI assistants can be a helpful aid for understanding material, and figuring out how to accomplish certain tasks for assignments. However, when used in an attempt to do entire assignments or projects, they hinder learning and will often provide incorrect answers. Therefore, if you use AI as an aid, please cite it in your submitted assignment and indicate which part of the assignment was helped by the AI assistant. If it is clear that an entire solution is direct output from AI, than you will receive a zero for the entire assignment.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

Late assignments will only be accepted without penalty if you have asked for permission (with GT-approved excused or for other extenuating circumstances) at least 24 hours before the assignment is due with a proposed date of submission. Otherwise, assignments submitted later than the end of class time on the day that they are due will automatically be deducted 20% credit. Assignments will not be accepted more than 24 hours late (i.e. you will receive no credit for the assignment) unless you have received prior permission.

Inclement Weather and Digital Learning Days

If a weather-related event affects campus operations, class may be cancelled or pivoted to digital instruction. Read more about the policy regarding the requirements, procedures, and responsibilities related to Digital Learning Days for Modified Campus Operations.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The Student-Faculty Expectations articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom

A smartphone is not permitted for use during class time unless it is an emergency or other extenuating circumstances arise. Students may use a laptop or tablet to take notes.

Campus Resources for Students

Undergraduate Student Academic Success Resources

A list of resources for undergraduate students' academic success and information about advising can be found at Success at Tech.

- Academic Support: The Office of Learning and Academic Success Initiatives (a division of the Office of Undergraduate Education & Student Success, Academic Success & Advising) provides free support for your courses. Students can attend scheduled supplemental review (PLUS) sessions, stop by Drop-In Tutoring, or schedule a one-on-one appointment through Knack. To explore what options work best for you, please visit us online at success.gatech.edu/tutoring, email us at tutoring@gatech.edu, or come see us at Clough Undergraduate Learning Commons, Suite 283.

Graduate Student Academic and Professional Success Resources

A list of resources for graduate students is given on the Office of Graduate and Postdoctoral Education website. Specific information for current graduate students includes:

- Academic Resources such as the Communications Center, Language Institute, Library, Catalog, Registrar, resources for conducting research, Advocacy and Conflict Resolution resources, and how to manage unexpected situations that may impact your academic performance;
- Student Resources such as Campus Services, Child Care/Family programs, Health & Wellness, Career Services, and the Student Resource Guide; and
- Professional Development such as the programming from the Career Center and other professional development resources and events"

Student Well Being

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person.

Georgia Tech Resources

- The Office of the Dean of Students | **404-894-6367** | 2nd floor, Smithgall Student Services Building; You also may request assistance here (Links to an external site.)
- Counseling Center | **404-894-2575** | Smithgall Student Services Building 2nd floor
    - Services include short-term individual counseling, group counseling, couples counseling, testing and assessment, referral services, and crisis intervention. Their website also includes links to state and national resources.
    - *Students in crisis may walk in during business hours (8am-5pm, Monday through Friday) or contact the counselor on call after hours at **404-894-2204**.*
- Disability Services | **404-894-2563**
    - The Office of Disability Services collaborates with students, faculty, and staff to create a campus environment that ensures all students have an equal opportunity to access the Georgia Tech community.
- Students' Temporary Assistance and Resources (STAR)
    - Can assist with interview clothing, food, and housing needs.
- Stamps Health Services | **404-894-1420**
    - Primary care, pharmacy, women's health, psychiatry, immunization and allergy, health promotion, and nutrition
- OMED Educational Services| 404-894-3959
- Belonging and Student Support
- Georgia Tech Police | 404-894-2500

National Resources:

- The National Suicide Prevention Lifeline | 1-800-273-8255
    - Free and confidential support 24/7 to those in suicidal or emotional distress
- The Trevor Project
    - Crisis intervention and suicide prevention support to members of the LGBTQ+ community and their friends
    - Telephone | **1-866-488-7386** | 24 hours a day, 7 days a week
    - Online chat (Links to an external site.) | 24 hours a day, 7 days a week
    - Text message | Text "START" to **687687** | 24hrs day, 7 days a week

Course Schedule

Date	Topic	Notes, Readings, due dates
Week 1	Preliminaries: what is a glacier, where are glaciers, history of ice on Earth, glacial cycle models	(CP Ch. 13.3)
Week 2	Surface mass balance: accumulation, ablation, equilibrium line, surface energy balance, height-mass balance feedback, mass balance measurements	(CP Ch. 2, 4-5, 11)
Week 3	Ice flow: the continuity/advection equation, continuum mechanics, stress and strain, rheology, constitutive laws, plastic and viscous flow, non-newtonian fluids	(VDV Ch. 1-2, CP Ch. 3)
Week 4	Ice flow: Cauchy momentum equation, Stokes flow, the many flow approximations	(VDV Ch. 3-4)
Week 5	Ice temperature: thermal classification of glaciers, heat equation, steady-state approximation	(VDV Ch. 6, CP Ch. 9)
Week 6	Ice-bed interface: cavitation, regelation, till	(CP Ch. 7, VDV CH. 7)
Week 7	Glacier hydrology: supra-, en- and sub-glacial drainage systems, drainage models, flow through porous media	(CP Ch. 6)
Week 8	Glacial geophysics: ice-penetrating radar, seismic methods	
Week 9	Radar Labs	
Week 10	Finish subglacial hydrology, marine ice sheets	
Week 11	Spring Break	
Week 12	Ice-Ocean interactions, Fracture	
Week 13	Ice streams. Sea Level: gravity, glacial isostatic adjustment, future sea-level rise	

Date	Topic	Notes, Readings, due dates
Week 14	Sea Level continued. Planetary Ice.	
Week 15	Final project office hours and lightning talks.	
Week 16	Final Project lightning talks (7 minutes talk + 4 minutes discussion)	

Latest version as of April 9, 2026