

COMPUTATIONAL ASTROPHYSICS

Tuesday & Thursday | Classroom | 2:00-3:15p

Zoom (see Canvas)

Contact Info

Prof. Stella Offner

My pronouns: she/her/hers

Help Sessions:

Tu 12:00-1:00

Or by appointment

Location: Zoom (see Canvas) or
PMA 15.312A

Email:

soffner@astro.as.utexas.edu

Or via Canvas message

What is AST 381 all about?

This course provides an introduction to advanced computational techniques used for numerical simulations in astrophysics. The focus will be on high-performance computing used in current astrophysics research. It will be hands-on: you will write your own code to implement basic numerical methods for modeling hydrodynamics, dig into the "black boxes" of public astrophysical codes, and gain experience in high-performance computing by running calculations on Texas Advanced Computing Center (TACC) facilities. The course content is divided into 6 parts focusing on different numerical methods, each of which has a physics theme:

1. Grid-Based Methods / Hydrodynamics (Lectures 2-6)
2. Particle-Based Methods / Gravity (Lectures 7-10)
3. Monte Carlo & Ray Tracing / Radiation (Lectures 11-15)
4. High-Performance Computing / TACC (Lectures 16-18)
5. Lagrangian & Hybrid Methods / Magnetohydrodynamics (Lectures 19-21)
6. Miscellaneous Topics (Lectures 22-25)

Email Policy: Email at any time with questions specific to your personal situation! Note: no permission is needed to miss class. For questions about class procedure and grading, **first** check this syllabus.

Course Learning Objectives: You will...

- Understand the landscape of astrophysical methods currently in use and their strengths and weaknesses.
- Be able to evaluate the accuracy of numerical modeling in the literature and think critically about the robustness of the results.
- Obtain experience writing your own methods and using public astrophysical codes.
- Be able to validate the efficiency and scalability of parallel numerical methods.
- Obtain experience using TACC and writing a computing proposal.
- Know where to find resources needed to develop methods from scratch

Reading & Resources:

Class content is drawn from a broad range of reference materials, including review articles and textbooks. Many of these sources are free and available online. Any that aren't can be found on reserve in the PMA library.

Online:

- "Introduction to Astrophysical Computational Hydrodynamics" by M. Zingale
- "Grid-Based Hydrodynamics in Astrophysical Fluid Flows" ARA&A by R. Teyssier
- Feynman Lectures, Vol II Chpt 40, 41
- "Computer Simulation with Particles" by Hockney & Eastwood
- "Monte Carlo Radiative Transfer" living review by Noebauer & Sim
- "SPH Methods in the Modeling of Compact Objects" by S. Rosswog
- "Radiative Processes in Astrophysics" by Rybicki and Lightman

On Reserve:

- "Gravitational N-body Simulations" by Aarseth
- "Numerical Recipes" by Press et al.,
- "Computer Architecture: A Quantitative Approach" 6th addition by Hennessy & Patterson
- "Computational Physics" by Thijssen

What is expected of me in this class?

- Attend class (online or in-person) and **participate!** Be prepared to discuss, ask questions and share your ideas.
- Complete all assignments on time. Work collaboratively on the homework. Ask for help if you have questions!
- Do all the suggested reading and more. It is to your advantage to read as many different sources as possible and seek your own supplementary reading material. Many of the specialized texts we use could each be the topic a graduate course. It is my goal that you know where to find the relevant content if you need it for your research.
- Don't procrastinate on the homework, especially the final project!

What happens in lecture?

- My goal is that you learn mostly by *doing* (e.g., reading, HW, discussions and the project), rather than only listening.
- A typical class will start with a *brief review* of the previous class and include opportunities to discuss, short activities and time for questions.

Classroom Safety and COVID-19

There are several important ways YOU can help preserve the safety of our learning environment:

- **Wear a face covering** that covers your mouth and nose to in-person classes. Face masks are no fun, but they are an important way to reduce community spread. As per university policy, masks are *highly recommended* but not required. See [university mask guidance](#).
- **Maintain social distance as much as possible in the classroom.** Leave an empty seat between you and your neighbor.

- **If you feel ill or have a positive COVID test please *DO NOT* come to class in person.** The class notes will be posted online after class.
- **Get vaccinated and boosted.** [Vaccinations are widely available](#), free and not billed to health insurance. The vaccine will help protect against the transmission of the virus to others and reduce serious symptoms in those who are vaccinated.
- **Get tested.** If you are experiencing any symptoms of COVID-19, please follow [university guidelines](#), including getting tested. If you test positive, you should isolate yourself at home. Contact the [Behavior Concerns and COVID-19 Advice Line \(BCCAL\)](#) to report your positive result. BCCAL can also assist you with isolation options, class absence notification or other support.
- **[Proactive Community Testing](#)** remains an important part of the university's efforts to protect our community. Tests are fast and free, and I recommend testing at least once weekly.
- Visit protect.utexas.edu for more information.

Modality

To maximize learning and safety for everyone through the end of January I will teach the class over Zoom. When it is safe to do so we will return to class in person.

Zoom Etiquette: All classroom norms apply when in a Zoom session. If you wouldn't do something in a physical class, don't do it in a digital classroom. Please ensure that your microphone is working before class. You will be working with other students in breakout rooms during lecture periods and conversing with your classmates will be an important part of the experience. **Mute your audio whenever you are not speaking.** I will try to monitor the chat. If I don't see your question, unmute yourself and ask your question.

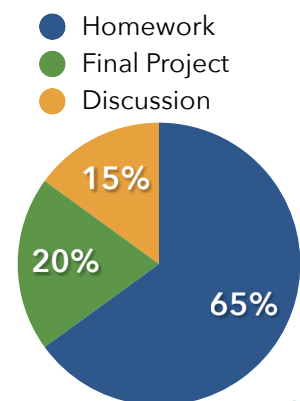
Video: Please keep your video on when in the main classroom to help us maintain a personal connection (this is especially true when in small breakout rooms). When in breakout rooms, you are required to have your video on, unless you let me know ahead of time why you cannot use video. You may use appropriate video and Zoom backgrounds.

Breakout Rooms: Breakout Room discussions should be structured and on topic. Take turns sharing ideas without a single person dominating the discourse. I will drop in at random to listen in, promote the discussion, and answer questions.

How is my performance in this class assessed?

Your final course grade will be determined as follows:

65% - Homework There will be 6 homework assignments. Homework is due on Friday of the week it is assigned by 5. If you cannot hand in the homework (e.g., due to illness), contact me to let me know as soon as possible. Extensions will be given depending on circumstances.



20% - Final Project You will propose and complete a final project using the Gizmo code. This will include running calculations on TACC, analyzing/visualizing the simulation data, and submitting a project writeup.

15% - Discussion and Class Participation: You will receive credit for this component by (1) asking questions, participating in class discussion and being an active participant in (class/breakout room) discussions/activities (5%), (2) presenting a journal article to the class (5%), and (3) discussing and presenting your final project to the class.

There will be no final exam.

What are other policies on assignments and course structure?

Course Website:

<https://utexas.instructure.com/courses/1324846>

Course Webpage: The course webpage on Canvas will be updated with course announcements and homework deadlines. It is your responsibility to check these on a regular basis. Please come to class prepared to participate in in-class discussions and activities – this is for your benefit!

Late work: If you cannot hand in a homework (e.g., due to illness) or the project on time, contact me to let me know as soon as possible. Extensions will be given depending on circumstances.

Course Conduct: Please silence cell phones before you enter the classroom. **No texting or using your cell phone** during class except for use in specified classroom activities. Please do not leave class early unless you have talked to me in advance, as a consideration to me and your fellow students. Students are encouraged to bring laptops to class to take notes and participate in some class activities. Laptops should not be used for non-class activities; students using their computers for non-class activities are a distraction to those around them. If laptop distraction becomes a problem, I reserve the right to reverse this policy.

What is the grading scale?

93.0 - 100 A
90.0 - 92.99 A-
87.0 - 89.99 B+
83.0 - 86.99 B
80.0 - 82.99 B-
77.0 - 79.99 C+
73.0 - 76.99 C
70.0 - 72.99 C-
67.0 - 69.99 D+
63.0 - 66.99 D
60.0 - 62.99 D-

Be respectful of others, especially during in-class discussion, and even if you disagree with them.

Students with Children: I recognize the difficulty of being a full time student with children. If you have children, or other family commitments, please contact us to discuss any modifications of the course policies which will maximize your success in this course.

Email: Email is recognized as an official mode of university correspondence; therefore you are responsible for reading your email for university and course-related information and announcements. Please check your email regularly and frequently.

Administrative Deadlines: It is your responsibility to keep track of the administrative deadlines for dropping the course, changing to Pass/Fail etc.

Syllabus Changes: I reserve the right to make changes to the syllabus and class schedule if necessary. If any changes are made they will be announced through Canvas and new versions will be uploaded.

Equity & Inclusion:

Please see this university [Resources Page](#) for a list of student resources. Note all faculty members, including myself, are also resources.

The University of Texas President's statement of community values can be found [here](#).

Astronomy belongs to all people, independent of race, religion, gender, gender identity, gender expression, or sexual orientation. It is important to me that **all** students feel welcome and comfortable in our UT astronomy community and are able to be their authentic selves.

Incidents of discrimination, assault, harassment, threats, intimidation, profiling, or coercion based on membership or perceived membership will not be tolerated.

Land Acknowledgement:

I would like to acknowledge that we are meeting on the Indigenous lands of Turtle Island, the ancestral name for what now is called North America.

Moreover, I would like to acknowledge the Alabama-Coushatta, Caddo, Carrizo/Comecrudo, Coahuil-tecan, Comanche, Kickapoo, Lipan Apache, Tonkawa and Ysleta Del Sur Pueblo, and all the American Indian and Indigenous Peoples and communities who have been or have become a part of these lands and territories in Texas. These people observed the night skies and marked the passing of the seasons here long before the founding of Texas.

Where can I find..?

Canvas will have:

1. Important announcements
2. Lecture slides
3. Weekly assignments and modules
4. Syllabus
5. Gradebook

Canvas will be our main form of communication, so check it regularly and stay up to date on assignments and communications.

Frequently Asked Questions:

What about technical difficulties?

If you have a technical problem that causes you to miss a class while on zoom, you'll be able to catch up using the posted class notes and recordings. If **my** internet goes out during class, don't leave! I will log back in via my phone and continue the class (I will also strive to upload lecture PDFs before class so you can follow along).

Do you record the in-class lectures?

Yes! Links for the recordings will appear under "Cloud Recordings" found on the Zoom tab on the class Canvas page. This tab is along the left side navigation.

I'm sick and can't come to class today, what do I do?

You don't need to email me! Stay home and get better. Download the PDF and watch the class recording to see what you missed.

University Resources:

Student Support: COVID-19 Updates and Information: This course may have changes, we all will need to be flexible with the learning environment depending on changing situations. But I will do my best to build in flexibility and options for you to be successful in this course. To help yourself, please explore the resources available here: <https://protect.utexas.edu/students-families/>

Academic accommodations (SSD): This class respects and welcomes students of all backgrounds, identities, and abilities. If there are circumstances that make our learning environment and activities difficult, or if you have medical information that you need to share with me, please let me know. I am committed to creating an effective learning environment for all students, but I can only do so if you discuss your needs with me as early as possible. I promise to maintain the confidentiality of these discussions. Any student with a documented disability who requires academic accommodations should contact Services for Students with Disabilities at 471-6259 (voice) or 512-410-6644 (Video Phone) as soon as possible to request an official letter outlining authorized accommodations. For more information, visit <http://ddce.utexas.edu/disability/about/>. *I am also happy to meet with you to discuss your situation.*

Counseling and Mental Health Center: Do your best to maintain a healthy lifestyle this semester by eating well, exercising, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. <http://www.cmhc.utexas.edu/individualcounseling.html>

University and Course Policies:

Academic integrity: The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the university is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community. Students who violate University rules on scholastic dishonesty are subject to disciplinary penalties. Ethical conduct is expected at all times.

You are responsible for understanding UT's Academic Honesty and the University Honor Code which can be found at the following web address: <https://deanofstudents.utexas.edu/conduct/standardsconduct.php>

- **Sharing of Course Materials is Prohibited:** No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (projects, homework assignments), and in-class materials, may be

shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

- **Class Video Recordings:** Class recordings are reserved only for the use of members of this class (students and the instructor) and only for educational purposes and are protected under FERPA. Recordings should not be shared outside the class in any form. Violation of this restriction could lead to Student Misconduct proceedings.

Plagiarism: is defined as using *another's words, code, solutions or ideas without credit*. This includes copying text from a source without using quotation marks or using code you didn't write *and* including the source reference. **You are encouraged to work together on homework and the final project but each student must turn in their own unique solution set.** Plagiarized assignments will receive a zero. As a research university, the University of Texas at Austin takes plagiarism very seriously. Do not risk getting involved in a plagiarism infraction - the consequences simply aren't worth it. Always cite your sources, and when in doubt consult a professor or librarian. See the Student Judicial Services website: <http://deanofstudents.utexas.edu/conduct/academicintegrity.php> Incidences of academic dishonesty will be reported to Student Judicial Services.

Personal or Family Emergencies: If you experience a personal or family emergency (death in the family, protracted sickness, serious mental health issues) that forces you to miss multiple days of class, you should contact Student Emergency Services in the Office of the Dean of Students <http://deanofstudents.utexas.edu/emergency/>. They will work with you to communicate with your professors and let them know of your situation.

Religious Days: A student who misses a class for the observance of a religious holy day will be permitted to make up the missed work, if notice is given at least fourteen days prior to such an absence.

Title IX: Beginning January 1, 2020, Texas [Senate Bill 212](#) requires all employees of Texas universities, including faculty, report any information to the [Title IX Office](#) regarding sexual harassment, sexual assault, dating violence and stalking that is disclosed to them. Texas law requires that all employees who witness or receive any information of this type (including, but not limited to, writing assignments, class discussions, or one-on-one conversations) must be reported. If you would like to speak with someone who can provide support or remedies without making an official report to the university, please email advocate@austin.utexas.edu. For more information about reporting options and resources, visit <http://www.titleix.utexas.edu/>, contact the Title IX Office via email at titleix@austin.utexas.edu, or call 512-471-0419.