SYLLABUS
ASTR 400A • Theoretical Astrophysics • Fall 2021

MODALITY: This class is scheduled to be taught in the in-person modality.
LECTURES: Tuesday/Thursday: 12:30 p.m. - 1:45 p.m.
Steward Observatory, Room 204

INSTRUCTOR: Dr. Nathan Smith
OFFICE: Steward Observatory, room N512
EMAIL: profsmith170@gmail.com
OFFICE HOURS: Tu/Th (2:00 p.m. – 3:00 p.m.) on Zoom, or by appointment

TEACHING ASST: Mr. Yujing Qin (pronounced like "Eugene")
OFFICE: Steward Observatory, room 302
EMAIL: qinyj@email.arizona.edu
OFFICE HOURS: M/W (3:30 p.m. – 4:30 p.m.) Rm. 208 or on Zoom, or by appointment

MIDTERM EXAMS: held during class time on D2L and email
Midterm 1, Thurs. Sep. 16, Chap 1, 2, 3
Midterm 2, Thurs. Oct. 14, Chap 4, 5, 6, 7
Midterm 3, Tues. Nov 11, Chap 8, 9, part of 10
FINAL EXAM: Wednesday, Dec 15, 1:00 p.m. - 3:00 p.m., Chap 1-12, on D2L and email

REQUIRED TEXTBOOK: *An Introduction to the Theory of Stellar Structure and Evolution* by D. Prialnik (Cambridge) *2nd edition*

OTHER USEFUL TEXTS (not required):
Stellar Interiors by Hansen, Kawaler, & Trimble (2nd edition)
Stars and Stellar Processes by M. Guidry
An Introduction to Modern Astrophysics by Carroll & Ostlie

COURSE WEBSITE: http://D2L.arizona.edu
ZOOM LINKS: https://arizona.zoom.us/j/82434426980 (link also on D2L). Passcode: astr400a
This link is for **Prof. Smith's Office Hours and Lecture (if needed).**
TA Office Hours: Zoom Meeting https://arizona.zoom.us/j/83879449570

PREREQUISITES: MATH 254 and 12 units of upper division physics are prerequisites. ASTR 300A and 300B strongly encouraged.

COURSE OVERVIEW: This course is a continuation of the series of required major courses, following 300A&B. The main topic of the course is a focus on understanding stellar structure and evolution, a field of astronomy that brings many different branches of physics to bear on the fundamental objects of astronomical study—stars. Toward the end of the semester, we may discuss other related topics as well, including observational studies of transients, compact objects, gravitational waves, star and planet formation, and feedback from stars and its influence on the hydrodynamics and thermodynamics of the ISM.

TOPIC SCHEDULE & READING ASSIGNMENTS:
(Assigned chapters must be read before class on Tuesday of the listed week)

Week	Topic	Chapters	Notes
1. Aug 24/26	Introduction/overview/observed properties	1	…
2. Aug 31/Sep 2	Equilibrium, Virial Theorem, timescales	1, 2	HW1(T)
3. Sep 7/9	Gas & radiation physics, pressure sources	3	HW2(Th)
4. Sep 14/16	Transport of energy	3	Midterm Exam 1 (Th)
5. Sep 21/23	Nuclear energy generation	4	HW3(Th)
6. Sep 28/30	Nuclear (cont.), stellar structure, simple models	4,5	project outline due (Th)
7. Oct 5/7	Stability, simple evolution of stellar interior	6, 7	HW4(T)
8. Oct 12/14	Interior (cont.)	7	Midterm Exam 2 (Th)
9. Oct 19/21	Mass loss, Evolution of Low-mass Stars	8,9	HW5(T)
10. Oct 26/28	White Dwarfs, Novae, Supernovae	9	…
11. Nov 2/4	Evolution of high-mass stars, HRD	9	HW6(T)
12. Nov 9	Midterm 3 (T), **VETERANS DAY (Th, no class)**	10	Midterm Exam 3 (T)
13. Nov 16/18	Supernovae, GWs, neutron stars, black holes	10	HW7(T)
14. Nov 23	Interacting binary stars	11	11/26 = Thanksgiving
15. Nov 30/Dec 2	Binaries (cont.), ISM	11,12	HW8(T), Projects due (Th)
16. Dec 7	Star formation	12	HW9

Wednesday Dec 15 **Comprehensive Final Exam 1:00-3:00 pm**

COURSE OBJECTIVES and LEARNING OUTCOMES:

- Demonstrate the ability to meaningfully analyze, apply and integrate the principle findings, common applications, current problems, fundamental techniques, and underlying theory of stellar structure and evolution at an advanced level.

- Employ discipline skills related to the observational techniques and theoretical analysis used to investigate modern astrophysical phenomena and problems.

- Combine skills, knowledge, principles, and equations from many scientific disciplines including nuclear physics, fluid dynamics, thermodynamics, radiation, and chemistry, and employ them together to investigate the complex interior structure and evolution of stars.

- Develop proficiency with analyzing, interpreting, and presenting astrophysical concepts in oral and written formats.

- Develop mastery knowledge and understanding of the theory of stellar structure and evolution, and connect it to complex observed evolutionary properties of stars.

GRADING: Your final grade for the course will be based on total points you earn out of 800 possible points for the midterm/final exams and other assignments in the following proportion:

Homework/Prep./Group	240 pts (30%) drop lowest HW, and 2 lowest part.
2 Midterm Exams	120 pts (15%) x 2 (drop lowest of 3)
Project	120 pts (15%)
Final Exam	200 pts (25%)

Letter grades will not be given for each individual assignment, but we will give feedback for large-value items like mid-term exams and the project. If you would like feedback on your individual homework assignments, please come to office hours or schedule an appointment with Prof. Smith. Mistakes in grading individual assignments sometimes happen. All questions, disputes, or mistakes regarding the grading of exams and assignments must be brought to our attention within 1 week after the assignment is handed back or posted; such checks are encouraged. We reserve the right to change or curve the course grading, but a guideline for percentage vs. grade is as follows:
A = 90% B = 80% C = 70% D = 60% E < 60%

PREPARATION, HOMEWORK, AND IN-CLASS GROUP WORK: This course will emphasize problem solving, individually and in groups, both in class and individual homework. This will constitute much of the class time, with less emphasis on traditional lecturing. In other words, students will participate actively in the lecture session, sometimes being asked to present solutions to homework problems, or to discuss or solve new problems in groups. This in-class work will be a significant part of your grade (about half of the homework/participation component). It is therefore essential that students come to class ***prepared***, having done the relevant reading and homework in advance. With the exception of the first 2 days of class, students are expected to have read relevant chapters in the text (as noted above) before class, and to have completed the homework before class on due dates. Since we will go over homework problems in class, no late homework will be accepted. However, we will drop the ***lowest*** homework and ***two lowest*** participation scores. Dropping these scores is meant to allow flexibility for any unforeseen disasters, illnesses, family emergencies, religious holidays, sporting events, late registration in the course, the bookstore running out of books, computer malfunctions, zombie attacks, etc. You may, of course, submit the homework problem set early. You may discuss the concepts with classmates, but you must do your own work (except for designated group work). Alternative make-up assignments will be given in the event of a medical absence with doctor's note/Dean's excused absence if lowest dropped scores have already been used up for previous absences.

MAKE-UP EXAM/HOMEWORK POLICY: We understand that occasional unavoidable absence or unforeseen circumstances may occur, especially in the current pandemic. For these normal situations (minor illness, mild injury, called in to work at the last minute, child is sick, other friend or family member needs help with Covid-19 related matter, oversleeping because your alarm didn't go off, etc.) we do not allow make-up assignments on the first (or second) instance. Instead, the grading of the course has some flexibility built in: i.e. we drop the lowest homework score and the two lowest participation scores, as noted above. After the one dropped homework is used up, late homework or makeup assignments will be allowed for missed homework that is due to serious illness (yourself or a family member) that is accompanied by a doctor's excuse or an excused absence from the Dean's office. If you must miss class because of a recognized religious holiday or other ***pre-scheduled event***, turn in your assignment early, and for an ecam, consult Prof. Smith at least one week ***BEFORE*** you miss a

class or exam. In these cases you will most likely take the exam early. Failure to contact Prof. Smith before missing an exam for any scheduled event will yield a score of zero on the exam (which may be OK once, because we drop the lowest midterm). There are some unforeseen severe cases that do justify a makeup opportunity for term papers and exams (or multiple homeworks) after a deadline or exam, such as a death in the family, prolonged or severe illness or injury requiring medical treatment, etc. Notify Prof. Smith by email as soon as possible in such circumstances.

TYPICAL RECIPE FOR SOLVING PROBLEMS: Much of the attention in this class will be spent on solving specific posed problems, either as in-class examples, group exercises, homework problem sets, or exams. In this course, I would like you to follow the list of steps given below when confronted with a problem to solve (even problems from the textbook). It may take more time to do a specific problem this way, but it is also likely to solidify your understanding more than just plugging and chugging. Moreover, showing your work by following these steps is more likely to convince me that you understand what you are doing and will provide me more opportunities to award partial credit in the event that you make a mistake somewhere. Unless otherwise noted, these are the steps you should generally follow (this will be discussed in class).

I. Draw a picture, if appropriate.
II. Explain in words how you intend to solve the problem; note any assumptions.
III. Write down equations that you will use, define any constants, and note the units of those constants.
IV. Without plugging in numbers, isolate the variable you want from the equations you have adopted.
V. Plug and chug to get a numerical answer, if that is requested in the problem.
VI. Interpret the result. Does the number make sense? Units? How would the result vary as you change parameters of the situation? Put it in context or give an astronomy application as appropriate.

Note that steps II & IV above provide partial fulfilment of a writing requirement because ASTR400A is designated as a writing emphasis course (the term paper also addresses this requirement).

MIDTERM EXAMS: There are three midterm exams scheduled throughout the course, as listed above. Each of these emphasizes material in the previous few weeks (i.e. not cumulative), with relevant text chapters noted. Although there are three midterms, your grade will be based on the two best performances, and the lowest of the three scores will be dropped. Midterm exams will take place during lecture time, but will be administered through D2L.

FINAL EXAM: Please note that the final exam is scheduled for Wednesday, December 15. Take this into account when making any holiday travel plans in December. The final exam is cumulative. The final exam will take place during the designated time, but will be administered through D2L.

TERM PAPER: All students are required to submit a written project as part of the requirements for this course. You must submit an early outline/sketch of your term paper topic in week 6 (this is required). The deadline for turning in your finished project is Thursday, Dec 2 (start of class). This deadline is firm; **absolutely no late term papers will be accepted except for a medical emergency**. Detailed instructions and guidelines for the project are available on D2L. On or before the due date, upload a PDF file to the course website (D2L) dropbox before the start of class. Failure to do this by the deadline will earn a score of zero on this assignment.

HONORS. Students who have registered for ASTR 400A as Honors Credit must satisfy additional requirements. This will include an Honors Project and additional steps in each homework Problem Set. See the Honors information on D2L.

ATOMM: You may wish to take advantage of **ATOMM: Astronomy Tutoring Offered for Majors and Minors** offered by our department. Your T.A., Yujing Qin, is one of the ATOMM tutors. Please see http://uaastroclub.org/resources/astronomy/atomm/.

PARTICIPATION IN CLASS: Participation points may be awarded at any lecture in the form of in-class exercises and group work or quizzes, and will figure into your final grade. Students are responsible for all information given out in the lecture, including any announced schedule changes, and so attendance is ***required***. If you must miss class, talk to another student, your instructor, or consult the D2L page to find out what you missed. We will conduct interactive group exercises in class; this will improve your understanding of the material and will count toward your grade. You will not be allowed to make up any missed participation points. To allow for unavoidable periodic absences, we allow two absences with no penalty. In other words, your two lowest participation scores will be dropped.

STATEMENT ON COMPLIANCE WITH COVID-19 MITIGATION GUIDELINES: As we enter the Fall semester, your and my health and safety remain the university's highest priority. To protect the health of everyone in this class, students are required to follow the university guidelines on COVID-19 mitigation. Please visit www.covid19.arizona.edu.

CLASSROOM ATTENDANCE: If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.

- Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.
- Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments. Please communicate and coordinate any request directly with your instructor.
- If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.
- Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus.
- If you test positive for COVID-19 and you are participating in on-campus activities, you must report your results to Campus Health. To learn more about the process for reporting a positive test, visit the Case Notification Protocol.
- COVID-19 vaccine is available for all students at Campus Health.
- Visit the UArizona COVID-19 page for regular updates.

LIFE CHALLENGES: If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students. The Dean of Students Office can be reached at DOS-deanofstudents@email.arizona.edu or 520-621-2057.

PHYSICAL AND MENTAL-HEALTH CHALLENGES: If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

ACADEMIC ADVISING: If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed. Call 520-626-8667 or email to advising@.arizona.edu

ACADEMIC INTEGRITY: Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work, exercises, and exams must be the product of independent effort unless otherwise instructed. Presentation of any work other than your own, in whole or in part, is considered a violation of the Code of Academic Integrity. Any other technique that gains unfair advantage over other students is also considered academically dishonest. Any incidents of academic dishonesty will be dealt with harshly according to the University of Arizona's Code of Academic Integrity: http://deanofstudents.arizona.edu/codeofacademicintegrity . Consequences can range from loss of credit on an assignment to full dismissal from the University, depending on the severity of the offense. In our class, the penalty for plagiarism, cheating on an exam, or computer fraud will be automatic failure of the course and, depending on the circumstances, we may seek your suspension or expulsion from the University.

STUDENTS WITH DISABILITIES: If you anticipate or experience issues related to the format or requirements of this course, please meet with Prof. Smith. We would like to discuss ways to ensure your full participation in the course. If you determine that formal, disability-related accommodations are appropriate, it is very important that you be registered with Disability Resources (621-3268; http://drc.arizona.edu) and notify Prof. Smith of your eligibility for reasonable accommodations well in advance of the first midterm exam. We can then plan how best to coordinate your accommodations.

BEHAVIOR IN CLASS: Lecture will be held in person until further notice. You are encouraged to speak up and ask questions during lectures. You are expected to be courteous and respectful to your classmates and instructors, and we ask that you strive to be inclusive in group exercises. There will be times when you split into groups; those are meant as times for you to help each other understand, not necessarily times to get the answer the fastest. Give everyone in the group a chance to speak. You should also be aware of the University's policies on disruptive and threatening behavior:
http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students
http://policy.arizona.edu/education-and-student-affairs/disruptive-behavior-instructional-setting

UA NONDISCRIMINATION AND ANTI-HARASSMENT POLICY: The University is committed to creating and maintaining an environment free from discrimination; see
http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy