

**Department of Astronomy and Planetary Science
AST 401/401L Observational Astronomy Syllabus**

2021 Fall

4 Credit Units (Combined AST 401/401L)
Corequisites AST 401 and AST 401L must be taken together
Updated August 23, 2021

Prerequisite: AST 280

Modes of Instruction:

AST 401 (Lecture)

- Meets Tuesdays and Thursdays 9:35 - 10:50am in HLC 3109. Currently students should attend in person if it is safe to do so and NAU is encouraging a fixed seating pattern. For those that are sick or quarantined, classes will also be livestreamed on Zoom at <https://nau.zoom.us/j/6032695475> (passcode 22). Slides and a recording of class will also be posted on BbLearn. Please login to Zoom with your NAU email so I know who is attending.

- Instructor: Dr. Chad Trujillo Email: chad.trujillo@nau.edu
Physical Office: Physical Sciences (#19) 312 Cell phone: 808-756-4393
Virtual Office: Zoom (passcode 22) <https://nau.zoom.us/j/6032695475>
One tap mobile +16699006833,,6032695475# US (San Jose). Once you join the Zoom room, I will get a notification that you are there. Please wait a few minutes after connecting so I have time to initiate connection. Office Hours: Tue 12:25pm – 1:25pm (Right after E&M II) and Wed 10am – 11am (Right after Quantum) and by appointment, all office hours will be on Zoom. These dates/times were chosen to have the least amount of conflict with student schedules. I cannot guarantee that I will be available via Zoom outside of office hours or without an appointment as I could be in another meeting, but you can always try.
Availability: Phone response will usually be within an hour if a message is left or a text message is sent (during normal business hours), weekday emails will generally be responded to in a day. Weekend emails may not be responded to until Monday.

- You can also send class questions or feedback anonymously to <https://goo.gl/forms/BSvNSPSML7WXMzm22>.

AST 401L (Lab)

- Meets Wednesdays 2:20pm – 4:50pm in Bldg. 19, Room 232 and 7:00pm – 9:30pm at the Campus Observatory.

- Instructor: Ed Anderson
Office: Physical Science (#19) 211
Office hours: Knock on Ed's door anytime, or by appointment.

Email: Ed.Anderson@nau.edu
Office phone: 523-7096

Course Purpose: The course will provide an introduction to the acquisition and reduction of modern astronomical data, emphasizing imaging, photometry, and spectroscopy. This is a technical vocational course, so although science will be discussed, it will be in the context of how astronomical observations are acquired and analyzed.

Course Student Learning Outcomes: After taking this course, students will be able to (1) operate an astronomical telescope, (2) gather data using an astronomical telescope, (3) understand the fundamentals of how a telescope works, (4) have familiarity with the wide variety of astronomical techniques and astronomical technologies available to the modern professional astronomer, and (5) be able to understand and assess the significance of recent events in astronomy.

Assignments / Assessments of Course Student Learning Outcomes: The majority of the assessments in this course will be through homework and the nighttime lab. In the homework, students will solve problems based on the course lectures and the textbook readings. The laboratory homework will provide an assessment of the hands-on technical portion of this course. Students will also be assessed based on course attendance and class participation. Additionally, there will be 2 term exams and 1 final exam. Exams are being given because (1) it is primarily an individual effort, which is an important aspect of research to practice, and (2) studies show that retention is improved when students are asked to recall information through testing.

Field Trips: There may be a field trip to the 4.3 meter Lowell Discovery Telescope depending on the status of visits due to COVID restriction. If this is possible (likely later in the semester), a signup for the dates will be announced during lecture and made available online.

Health and Safety: We are currently in a pandemic, and the latest thoughts from the CDC is that even fully vaccinated people can spread COVID-19 to the unvaccinated, which currently includes children under the age of 12 and the millions of immunocompromised people in our country. Vaccination is still the best way to ensure you do not wind up in the hospital, so if you are not yet vaccinated, please get vaccinated. To minimize COVID-19 spread, NAU has established a mask requirement where social distancing is not possible. This includes in our classroom and at the observatory.

I will have a limited number of masks available if you forget your mask. If you are quarantined or have any symptoms of any kind of sickness, please do not come to class. All classes will be live streamed on Zoom, slides will be made available, and recordings will be made available. If you attend the livestream or watch the video you will receive full attendance credit. NAU (and I) strongly encourage in-person attendance if possible because we will be better engaged in an in-person learning environment.

It is very likely that medical guidance will change over the course of the semester. This is a science class, and most of you are science majors. Because of this, I expect all of us to comply with the latest science and medical guidance as it changes throughout the semester as issued by the CDC.

Grading System: Letter grades will be assigned as follows: A at 90%, B at 80%, C at 70%, D at 60% and F below 60%. The requirements for grades may be relaxed based on class performance, but they will not be made more stringent.

- **Final Exam:** The registrar has decided that our final exam will take place on **Tuesday Dec 7 7:30am - 9:30am**. The final will be worth 15% of your grade. Material on the final exam (and all exams) will be limited to subjects that you have seen at least three times: once in homework, once in lecture and once in a reading. Last year, the final exam period marked the beginning of a 24 hour period where students could complete the exam online at their own pace. This is likely what we will do again this semester to protect against unexpected COVID issues.
- **Mid-Term Exams:** There will be two mid-term exams on Tue Sep 28 and Thu Nov 4. These will cover any material that you have done a homework about (and received feedback on). These will each be worth 5% of your grade.
- **Homework:** There will be 1 homework assigned most weeks of the semester except for the week before term exams (so you don't have homework due on the same week as an exam) and the last week (reading week). These will count for a total of 25% of your grade. These will usually be assigned through BbLearn on Thursday and be due the following Thursday by 11:59pm, also turned in through BbLearn. This is the largest part of your grade in the lecture course.
- **Attendance:** Attendance and in-class participation will each count towards 5% of the grade for a total of 10%.
- **Lab Reports and Term Paper:** There will be a lab due every week (due dates announced in lab) as well as a group term project. You may work together; however, it is essential that you individually understand the labs, as each lab builds on the previous lab. You are required to make observations at the campus telescope on Wednesday nights. The Lab Reports and Term Paper total 40% of your grade.
- **Extra Credit:** There is extra credit for attending any Astronomy and Planetary Science Colloquium, even virtually. Attend and write two paragraphs with the speaker's name and describe (1) the instrumental setup the speaker used, (2) one of the main conclusions, and (3) what the speaker might be doing in the future along this line of research. One colloquium is equivalent of 20% of a single homework, so if you attend 5 colloquia, it is the equivalent of 1 homework assignment. Lectures shorter than one hour do not count for this unless there are multiple lectures that fill an hour and you can summarize them all. Extra credit must be turned in within a week of the event.

Readings and Materials:

- **Suggested Textbook:** Birney, Gonzalez, Oesper, *Observational Astronomy*, Second Edition. There will be some readings from this book. This is available on Amazon for rental for \$17.99. I will provide any excerpts that are required reading for this course so you are not required to buy this book.

- Computer: You will need a computer to complete nearly all assignments and to attend class virtually. If you don't have one, you can use the department computer lab and also the Cline Library rents computers.
 - iClicker App: NAU is offering iClicker services through smartphones (iClicker Student app, formerly iClicker Reef) at no cost to students. This will be used throughout the semester for online polling. Information on how to use the app can be found here: <https://macmillan.force.com/iclicker/s/article/Getting-Started-with-the-iClicker-Student-App> . This is better than other polling methods because it links with BbLearn to provide performance metrics.
 - Required supplementary readings will be made available on BbLearn.
 - Calculator: A scientific calculator will be useful for in-class exams, and is much more functional than trying to use your phone. The Texas Instruments XI-30XIIS Solar (about \$10 on Amazon) requires no batteries and will last decades. The same model is at the NAU Bookstore for twice the price. The Cline Library also rents these for free.
 - Paper and pencil.
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Class Outline: Below is an approximate outline of the topics covered by week. These will be adjusted based on the pace of the class. Also, there is the possibility of in-person class cancellation or move to a virtual class in the event of adverse weather, terrorist threat, or pandemic. If I deem conditions unsafe, I will cancel in-person class and notify the class by email prior to 7:35am (2 hours before class) the morning of class. Anytime NAU is closed, this class will become a virtual class. If circumstances makes both in-person and real-time virtual class impossible, a virtual lecture will be made available online.

- Week 1 (Aug 24, 26): Introduction, Syllabus, Eyeball Astronomy, Archeoastronomy, Planets, Zodiacal Light, Artificial Satellites
- Week 2 (Aug 31, Sep 2): Eyeball Astronomy, Magnitudes I, Units, Celestial Sphere, Time, Precession of Coordinates, Luminosity, Rainbows and Snell's Law, Light
- Week 3 (Sep 7, 9): Optical Telescopes, Black-Body Radiation, Planck's Law, Wein's Law, Charge-Coupled Devices, Photometry, Magnitudes II, Flat Fielding
- Week 4 (Sep 14, 16): Signal-to-Noise, Photometry, Magnitudes, Atmospheric Effects, Rayleigh Scattering, Astrometry, Statistics, Colors, Filters
- Week 5 (Sep 21, 23): More Signal-to-Noise, Kepler's Laws, Binaries, Proper Motion, Precession, Catalogs, Interstellar Medium Effects
- Week 6 (Sep 28, 30): **Mid-Term Exam 1 on Sep 28**, Spectroscopy, Exoplanet Detection, Doppler Effect
- Week 7 (Oct 5, 7): Radio Astronomy, Cosmic Microwave Background, Spectrographs, Solar Astronomy, Fourier Transform, Stellar Astronomy, Point Sources
- Week 8 (Oct 12, 14): Point-Spread Function, More Signal-to-Noise, Resolved and Unresolved Sources, Adaptive Optics and Speckle Imaging
- Week 9 (Oct 19, 21): Distance Ladder, Gravitational Lenses, Nyquist Sampling, Relativity

- Week 10 (Oct 26, 28): Planning Observations, Supernovae, Nucleosynthesis, Planetary Astronomy, Ephemerides, Kepler's Laws
 - Week 11 (Nov 2, 4): Keplerian Orbit, Occultations, **Mid-Term Exam 2 on Nov 4**
 - Week 12 (Nov 9): Infrared Astronomy, Radioactive Decay, Mid-Infrared Astronomy, Meteoritics, Cosmic Rays, **No Class Nov 11, Veteran's Day**
 - Week 13 (Nov 16, 18): Meteorites, Craters, Interplanetary Dust Particles, Vera Rubin Observatory, Time Domain Astronomy
 - Week 14 (Nov 23): Outbursts, Image Archives, Gravitational Waves, X-ray and Gamma Ray Astronomy. **No class Nov 25 (Thanksgiving)**
 - Week 15 (Nov 30, Dec 2): Review, AST 580 Presentations, Knowledge Contest.
 - **Final Exam (Tue Dec 7 7:30am – 9:30am)**
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Class Policies: Class policies are described below.

Lecture Attendance: You are expected to attend every Lecture if it is safe to do so. You may miss 2 Lectures over the semester without penalty (no excuse needed) if you notify Dr. Trujillo ahead of time. Institutional or medical excuses do not count towards the 2 classes you can miss. I will generally grant additional absences for research-related matters (conferences, etc.) provided I know in advance.

All lectures will be recorded and uploaded to BbLearn and are for class use only as per NAU policy. Therefore, if you intend to participate remotely but in real-time (like if you are sick) but have technical issues that prevent you from attending the class, you may watch the course after the fact. You have 24 hours from when the lecture is uploaded to watch the course to get attendance credit.

Lecture and Homework Policy:

- For all homework, as in life, you may work together. However, understand that solving problems by yourself is a core skill in academic inquiry. The submitted homework you must create yourself and any images submitted should be taken by you - in other words, you cannot copy and distribute images to other students. You must also reference other people that helped you with the homework. The reason for this is because in the real world, not attributing your sources does help a disservice at best and at worst is plagiarism, which is one of the greatest sins in academia.
- Calculations: There will be exercises where a calculation is required. In these problems, you must show your work **in enough depth that a typical student in the class could follow your reasoning**. This is because (1) if you make a mistake in computing the final answer, you can still get partial credit for the approach you use and (2) when doing example calculations in real life (such as in a published paper or thesis), you will have to show your work so that others can follow.

- Late policy: you can turn in 3 Lecture Homework assignments in this course 3 days late (due on Sunday at 11:59pm) for full credit if you notify me *prior* to the original deadline. No other excuse is needed. You cannot “bank” this time (turning in 1 assignment 9 days late) or “gift” your late assignment quota to others. The reason for this is that since you normally have a week to do each assignment, and it takes about a week to grade it after all assignments are turned in. So a more lenient late policy delays timely return of the homeworks to all students which makes it difficult to prepare for exams. No homework will be accepted beyond the 3 day extension.
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Exam Policy:

- Due to potential pandemic restrictions, I am planning that all exams will be taken through BbLearn. There will be a time limit, and exams must be taken concurrently with in-class students. Exams will be open note and the internet can be used as a resource since restricting this is basically impossible. That said, you will be much better off studying for the exam ahead of time rather than trying to find solutions on the internet due to the complexity of the problems. Required physical constants will be supplied as will fundamental formulae. Final formulae will not necessarily be provided as sometimes you may have to derive formulae yourself based on given constants and formulae depending on the problem.
 - Exams are designed to test individual knowledge. However, there will be opportunities for group work on tests, but these will be clearly announced ahead of time. In the absence of such an announcement, working together on a test, even virtually, is considered cheating.
 - Exams may not necessarily be taken in person due to pandemic restrictions. One week ahead of each exam, the exam policy will be announced, which will be guided by current NAU and CDC guidelines on pandemic restrictions. An opportunity for feedback will be given.
 - As in the homework, all work must be shown for full credit.
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Plagiarism and Cheating: Plagiarism is using someone else’s work or ideas and passing them off as your own (and in fact, you can even self-plagiarize, but that’s probably not relevant to this class). It is considered the most serious breach of scientific integrity. Evidence of this is work suspiciously similar to other’s work (exact same wording, or very similar wording) with no attribution. This is considered cheating in this course. All people involved in cheating and/or plagiarism will be given a zero on the assignment / exam and the Department Chair will be informed, regardless of who cheated off whom. Repeat offenses will be escalated to the Dean following the NAU Academic Integrity Policy.

E-learning Resources Policy: Much of our course work will take place electronically, including (but not limited to) out-of-class communication, presentation of reading materials, distribution of homework and virtual lectures. It is the responsibility of the student to check email and BbLearn regularly. The student must also allow ample time prior to deadlines to navigate any technological issues that may arise such as computer crashes, internet outages, software version mismatches, etc. Students are also strongly

encouraged to back up all data. ITS has an excellent support network and students having issues with online learning are encouraged to contact them.

Academic Contact Hour Policy: The Arizona Board of Regents Academic Contact Hour Policy (ABOR Handbook, 2-224) states that for a 4 credit course such as this one, a student should expect to spend a **minimum** of 12 hours per week on average. Class time is 2.5 hours per week of Lecture and 2.5 hours per week of Lab. Therefore, at least 7 hours per week should be spent outside of class on homework, studying, preparation, and the nighttime lab.

Financial Hardship: If you are experiencing financial hardship that makes it difficult for you to meet the class requirements, please communicate with me and we will find an accommodation.

Disability Resources: If disability accommodations would benefit you, please contact me and/or the Disability Resource office at NAU. Many services and accommodations are available at no cost to NAU students.

University Policies: The following pages contain the NAU Policy Statements for Course Syllabi. They take precedence over anything earlier in this document.

COVID-19 REQUIREMENTS AND INFORMATION

Additional information about the University's response to COVID-19 is available from the **Jacks are Back!** web page located at <https://nau.edu/jacks-are-back>.

SYLLABUS POLICY STATEMENTS

ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full *Academic Integrity* policy available at <https://policy.nau.edu/policy/policy.aspx?num=100601>.

COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (ABOR Policy 2-224, *Academic Credit*), each unit of credit requires a minimum of 45 hours of work by students, including but not limited to, class time, preparation, homework, and studying. For example, for a 3-credit course a student should expect to work at least 8.5 hours each week in a 16-week session and a minimum of 33 hours per week for a 3-credit course in a 4-week session.

DISRUPTIVE BEHAVIOR

Membership in NAU's academic community entails a special obligation to maintain class environments that are conducive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not interfere with normal class activities or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's *Disruptive Behavior in an Instructional Setting* policy at <https://nau.edu/university-policy-library/disruptive-behavior>.

NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. Due to potentially unethical consequences, certain consensual amorous or sexual relationships between faculty and students are also prohibited as set forth in the *Consensual Romantic and Sexual Relationships* policy. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's *Nondiscrimination and Anti-Harassment* policy. EAO also assists with religious accommodations. For additional information about nondiscrimination or anti-harassment or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or visit the EAO website at <https://nau.edu/equity-and-access>.

TITLE IX

Title IX is the primary federal law that prohibits discrimination on the basis of sex or gender in educational programs or activities. Sex discrimination for this purpose includes sexual harassment, sexual assault or relationship violence, and stalking (including cyber-stalking). Title IX requires that universities appoint a “Title IX Coordinator” to monitor the institution’s compliance with this important civil rights law. NAU’s Title IX Coordinator is Elyce C. Morris. The Title IX Coordinator is available to meet with any student to discuss any Title IX issue or concern. You may contact the Title IX Coordinator by phone at 928-523-3515, by fax at 928-523-0640, or by email at elyce.morris@nau.edu. In furtherance of its Title IX obligations, NAU will promptly investigate and equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. Additional important information about Title IX and related student resources, including how to request immediate help or confidential support following an act of sexual violence, is available at <https://in.nau.edu/title-ix>.

ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), 928-523-6906 (TTY), 928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at <https://nau.edu/disability-resources/student-eligibility-process> or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU’s Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at <https://nau.edu/research/compliance/research-integrity>.

MISCONDUCT IN RESEARCH

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University’s Research Integrity Officer, Dr. David Faguy, who can be reached at david.faguy@nau.edu or 928-523-6117. More information about misconduct in research is available at <https://nau.edu/university-policy-library/misconduct-in-research>.

SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

Last revised August 1, 2021