

# ASEN 5519: Science of Autonomous Systems

## Fall 2023 Course Syllabus

### General Information

**Instructor:** Nisar Ahmed ([nisar.ahmed@colorado.edu](mailto:nisar.ahmed@colorado.edu)), Smead AES Dept.

**Time and Location:** Mon, Wed, & Fri 3:00 pm - 3:50 am, AERO N240.

**Course Website:** [canvas.colorado.edu](https://canvas.colorado.edu) (posted course materials, announcements, assignments, recorded lectures, etc.)

**Office Hours:** **TBD** (other times by appointment only)

**Course Textbook:** There is no required textbook for this course, though readings will be posted from various books and papers. Some recommended free/open-source reference books include the following:

P. Corke. ‘Robotics, Vision and Control.’ Springer Cham, 2nd ed., 2017. [DOI](#) (available for free as pdf e-book; a companion Matlab toolbox is also available).

N. Correll, B. Hayes, C. Heckman, and A. Roncone. ‘Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms.’ MIT Press, 2022. ISBN: 9780262047555. (available via [open access](#) ).

**Description** This (new) graduate course will cover basic principles and skills needed to formulate and conduct research pertaining to autonomous systems. Students enter the Autonomous Systems (AUT) graduate focus area with diverse backgrounds in engineering (aerospace, mechanical, electrical, etc.), computer science, and other technical disciplines (e.g. physics, applied math). As a result, they often have had little/no exposure or experience with technical concepts outside their ‘native field’ that will be essential later for careers in either industry or academia. Moreover, students interested in possibly pursuing research careers may have limited/no experience with basic research concepts and practices. This course aims to bridge these gaps by giving students a practical hands-on introduction to the interdisciplinary AUT research ideas, methods, and practices, i.e. the *Science of Autonomous Systems*.

Whereas most other introductory AUT courses focus on rigorous coverage of theory and algorithms that are generally applicable to any autonomous system (aerospace or otherwise), this course will instead focus on surveying and synthesizing fundamental ideas from these classes from a research perspective. Since autonomous systems research evolves at a rapid pace with each new advance in machine learning, artificial intelligence, computer vision, hardware, sensing and actuating mechanisms, programming languages, etc., this course will equip students with core knowledge needed to get started in the field, as well as develop the skills any good researcher needs to keep track of (and eventually

improve/redefine) the state of the art. To this end, and in view of the fact that much of aerospace research focuses heavily on vehicle systems, most material will be presented from the interdisciplinary lens of *autonomous robotics research*. Major topic coverage and course activities will include:

- Essential practices and skills for doing fundamental autonomous robotics research (including problem identification, formulation, evaluation, and technical communication);
- Survey of core autonomous robotics research topics;
- Software implementation of algorithms and simulation of autonomous robotic systems, e.g. using WeBots and ROS (Robot Operating System);
- Research ethics and professionalism (including standards for effective peer review and publishing reproducible research).

Students will complete programming projects related to vehicle navigation/localization, control, planning, perception, object search and tracking, information gathering, or other applications connected to their aerospace research/professional interests.

**Prerequisites/expectations:** There are no formal pre-requisites. However, students should: (1) have (or be willing to develop) demonstrable competency completing projects and assignments **on ones own** in a technical programming language (e.g. Matlab/Octave, Python, C/C++, C#, Java, Julia, etc.), as well as work with operating systems like Ubuntu Linux; (2) be willing to work in groups (remotely or in person) for larger project assignments; (3) be willing to go outside their comfort zone by engaging in robotics problems and applications that may be foreign to their prior/future work; (4) be curious and willing to learn in a self-guided, hands-on way about the inner workings of autonomous systems and robotics, especially as far as understanding the meaning and value of rigorous evaluation/publication standards for research; and (5) be comfortable with this being a brand new class (being experimentally taught and developed this semester for the first time) and being an active participant.

## Course Details

**Grading and Project Assignments** Course work will involve a mix of individual assignments and group projects. There will be no exams. Assignments will ensure that students demonstrate basic understanding of the course material. Projects will integrate and explore concepts and techniques covered throughout the course. Assignments are expected to consist of short response essays and/or programming problems for toy applications, as well as questions to guide development of and reporting on final project applications. A group final project will be developed over the course of the semester, and will serve in place of a final exam.

While collaboration is highly encouraged, students must as always contribute and produce their own original individual work in all circumstances, per the CU Honor Code.

**Grading breakdown:** assignment/project exercises: 40%; final project: 40%; class participation: 20% (students are highly encouraged to engage in guided group discussions, ask and answer questions during class, office hours, via e-mail/online forums, etc.). Note that group project report submissions will result in the same grade for all group members.

**Benefits and Learning Objectives** This course will enable students to:

1. acquire and apply principles and skills to formulate and conduct fundamental research pertaining to autonomous robotic systems;
2. develop and implement software to simulate, test, analyze, and evaluate the performance of developed solutions to research problems, using foundational knowledge acquired from other graduate coursework and guided self-study;
3. organize, communicate, and critique technical presentations rigorously and concisely.

**Tentative Course Schedule (subject to change)**

<b>Week(s)</b>	<b>Topic</b>
1	Course intro & overview
1-2	Survey of Topics in Autonomous Robotics
2-5	Basic Research Skills and Practices
5-6	Project Group Formation, Project Idea Presentations
7-8	Technical Communication; Project Implementation Phase 1
9-10	Project Phase 1 ‘Work in Progress’ Presentations and Peer Review
11-12	Research Ethics; Project Implementation Phase 2
13	Fall Break (No Classes)
14-15	Project Phase 2 ‘Final’ Presentations and Peer Review

**General Policies (please read carefully)**

**CLASSROOM BEHAVIOR** Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

**REQUIREMENTS FOR INFECTION DISEASES** Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases. The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

For those who feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the further guidance of the Public Health Office. For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

**ACCOMMODATION FOR DISABILITIES, TEMPORARY MEDICAL CONDITIONS, AND MEDICAL ISOLATION** Disability Services determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance.

If you have a temporary medical condition or required medical isolation for which you require accommodation, please contact the instructor via email as soon as possible. Because of FERPA student privacy laws, you are not required to state the nature of your illness or condition when alerting the instructor. "Doctor's notes" are not required for classes missed due to illness; campus health services no longer provide "doctor's notes" or appointment verifications. Also see Temporary Medical Conditions on the Disability Services website.

**PREFERRED STUDENT NAMES AND PRONOUNS** CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

**HONOR CODE** All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

**SEXUAL MISCONDUCT, DISCRIMINATION, HARASSMENT AND/OR RELATED RETALIATION** CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

**RELIGIOUS HOLIDAYS** Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must notify the instructor at least 2 weeks in advance to schedule make up for completing and turning in any assignment (see Course Details above).

See the campus policy regarding religious observances for full details.

**MENTAL HEALTH AND WELLNESS** The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.