

# ALGORITHMIC MOTION PLANNING

## ASEN 5254 SECTIONS 1 & 2

### FALL 2023

#### LECTURE INFORMATION

Tuesday and Thursday 4:00-5:15pm

Room: AERO N240

Video recording will be made available after each lecture on the course canvas page

#### INSTRUCTOR

Morteza Lahijanian

Office: AES 267

Email: [Morteza.Lahijanian@colorado.edu](mailto:Morteza.Lahijanian@colorado.edu)

Office hour: Wednesday 2-3pm and by appointment

#### COURSE DESCRIPTION

This class provides an overview of the “lessons” learned by the robot motion planning research community in the last 30 years. We will examine approaches based on potential functions, graphs (roadmaps and cell decompositions), and sampling methods. We will also examine task and motion planning techniques, as well as basic approaches in planning under uncertainty. More broadly, this class provides a set of *tools* that can be used in tackling new problems and enables the pursuit of complex research questions such as *planning for autonomous systems*.

#### PREREQUISITES

A significant part of the performance evaluations (homework, final project) will involve coding, implementing, and evaluating algorithms. This requires at least the knowledge of how to plot 2-D/3-D functions, manipulating arrays and other data structures in addition to standard constructs (loops, functions, etc.). C++ and Python are the preferred languages, but MATLAB is also acceptable. Basic knowledge of differential equations, linear algebra, and control systems is also required.

## GRADING AND EVALUATION

Classwork consists of some homework exercises worth 30%, a mid-term exam (mini project) worth 30%, and a substantive project worth 40% of the grade.

## COURSE TEXTBOOKS

Required:

- *Principles of Robot Motion: Theory, Algorithms, and Implementations*  
H. Choset, K.M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L.E. Kavraki and S. Thrun  
MIT Press  
2005  
e-book through CU library: <https://libraries.colorado.edu/record=b9646308~S3>
- *Planning Algorithms*  
Steven LaValle  
Cambridge University Press  
2006  
Free download: <http://lavalle.pl/planning/>

Additional Resources:

- *Probabilistic Robotics*  
S. Thrun, W. Burgard, and D. Fox  
MIT Press  
2005
- *Robot Motion Planning*  
Jean-Claude Latombe  
Kluwer, 1991.
- *Handbook of Robotics*  
B. Siciliano et al.  
MIT Press, 2018

## COURSE OUTLINE

- Planning to move
- Object representation, transformation, and kinematics
- Configuration space
- Gradient-based motion planning algorithms
- Discrete Search

- Sampling-based motion planning algorithms
- Motion planning with kinodynamic constraints
- Optimal motion planning algorithms
- Task and motion planning
- Motion planning under uncertainty

## COURSE SCHEDULE

- Week 2-9: weekly homework assignments
- Week 10-11: final project proposal
- Week 11: mid-term exam (mini project)
- Week 16: final project report

## 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 [classroom behavior policy](#), the [Student Code of Conduct](#), and the [Office of Institutional Equity and Compliance](#).

## REQUIREMENTS FOR INFECTIOUS 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](mailto:dsinfo@colorado.edu) for further assistance.

If you have a temporary medical condition or required medical isolation for which you require accommodation, contact the faculty instructor immediately. For assignment or exam accommodations, notify the faculty at least two weeks prior to the due date or exam date. Also see [Temporary Medical Conditions](#) on the Disability Services website.

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## 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 Student Conduct & Conflict Resolution: [honor@colorado.edu](mailto: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](mailto: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 resources for a variety of issues, 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, inform the instructor of such conflicts at least three weeks in advance.

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.