# CSCE 439/839: Robotics: Algorithms and Applications

## Instructor

Dr. Carrick Detweiler
Associate Professor
220 Schorr Center
School of Computing
University of Nebraska-Lincoln
Lincoln, NE 68508

402-472-2449
carrick _at_ cse.unl.edu
Office hours: Posted on Canvas and by appointment

## Teaching Assistant

Adam Plowcha
Office Hours: Posted on Canvas and by appointment

## Course Info

Lecture: MWF 10:30pm - 11:20pm in Avery 110
Lab: F 11:30pm - 12:20pm in Avery 110

## Course Description

Robots play an increasingly important role in our lives, from assembling our cars and cell phones to vacuuming our rugs and flying recon missions. To create systems that work in the real world, the field of robotics requires robust theory and algorithms that are tightly integrated with hardware that is designed with engineering expertise.

This will be a hands-on, lab-based course where you will implement the algorithms you learn about in class on a small balancing robot that you will build in lab. You will learn the fundamentals of robotics, as well as the cutting-edge in robotics research. Topics covered will include: control, navigation and path planing, obstacle avoidance, manipulation and grasping, and robotic vision processing. By the end of the course you will know why robots are not yet folding our clothes and driving our cars, but you will also learn what is needed to make these possible in the future.

You will interface with the embedded system that controls the robot by using learning to program in ROS (Robot Operating System: `www.ros.org`). Programming will be in either C++ or Python, with an emphasis on C++. By the end of the course you will have a deep understanding of the design, programming, and interfacing of robot systems. This will prepare you for cutting edge careers in industry and research.

## Course Website and Canvas/email Communication

The primary website used for the course is the Canvas page. In addition, similar materials can be found on the public webpage for the course: `http://cse.unl.edu/~carrick/courses/2022/439/`, however, the Canvas page should be used as the primary reference.

This syllabus is subject to change, you will find the most up-to-date version of the syllabus on the course website, as well as information on readings, assignments, and projects. Please make sure to check it regularly. I will send messages via canvas or email. You are expected to check both daily.

## Prerequisites and Requirements

**Prerequisites**: A grade of "P" or "C" or better in CSCE 231, CSCE 336 or ECEN 220 and CSCE 310, CSCE 310H, CSCE 311, SOFT 260, SOFT 260H or RAIK 283H CSCE336 or ELEC222 and CSCE 310/311 or equivalent programming experience, MATH 314, senior/graduate standing, or instructor permission.
**Mastery of**: C++ or other high-level languages, embedded systems, algorithm analysis.
**Familiarity with**: basic and advanced data structures, GNU/Linux operating systems, software development, linear algebra.
**Exposure to**: introductory Newtonian physics, probability and statistics.

## Course Required Materials

Readings and resources are available online.
Laptop highly recommend.

## Topics Covered and Outcomes

Topics include: open and closed loop control, reactive control, localization, navigation, path planning, obstacle avoidance, dynamics, kinematics, manipulation and grasping, sensing, robot vision processing, and data fusion. See the course website for a detailed course schedule.
**Mastery of**: algorithmic design, implementation, and adaptation to real robots operating in uncertain environments, application development on robots.
**Familiarity with**: robot design and analysis, robot control, localization and navigation, robot vision techniques.

## Assignments and Grading

All assignments are due via Canvas. Assignment due dates are announced in class. Your final grade will be composed of a number of components. These are:

| Percentage | Assignment |
|---|---|
| 10% | Participation, Engagement, and Quizzes |
| 20% | Homework |
| 45% | Labs |
| 25% | Final Project/Challenge |

## Participation, Engagement, and Quizzes

Participation and engagement in class and lab is critical in this course and counts for 10% of your grade. You are expected to be prepared for class and lab, do assigned readings, and ask questions during class and lab. Simply coming to class and lab is not sufficient for obtaining full marks for participation; you should actively participate in discussions. There will be self and group evaluations of your lab team during the semester. If you do not put in the time and effort and contribute to the success of you lab group you will loose points.

There will be regular quizzes of varying length and points. Some will be announced and others will not be announced. These will cover topics from class, lab, online lectures, online videos, online readings, and other assigned materials. Quizzes are open book/internet, but collaboration with others is not allowed.

It is acceptable to use computers to take notes. However, I expect that their use will not be a distraction. Texting, tweeting, facebooking, etc. can wait until after class, unless you are saying really good things about

the course!

## Homework

There will be at least two homeworks over the course of the semester. These are **individual** assignments. It is ok to discuss concepts behind the problems in the homeworks with classmates, however, you cannot do them together. If you do discuss problems with classmates or other people, you must acknowledge this on the assignment (this will not lead to any grade reduction). As a metric for what level of discussion is allowed, it is ok to meet and talk over coffee about the assignment. It is not ok to show someone your solution or to work on the details of the problems together. In general any discussions should be limited to discussion and you should not be taking significant notes on the problems. If in doubt, ask me questions about assignments.

Homeworks are due via Canvas at the time specified on the Canvas assignment. **Late homeworks will receive a 15 point deduction per 24 hours late.** That means that if you turn it 1 minute late, you will start with a 85% as the highest possible grade.

## Labs

There will be three or four labs during the semester. These will be long, multi-week, group assignments. Each lab group only needs to submit one lab report. The lab report should be well written with complete sentences and paragraphs and be readable on its own. It must contain an introduction, discussion, conclusion, as well as the answers to specific questions asked. Supporting materials such as pictures, code examples, etc. are encouraged.

Each lab group will appoint a group member at the start of each lab that will be primarily responsible for collecting and organizing the lab report. Each person must do this for at least one lab during the semester. Everyone in the group must contribute fully to doing and writing the lab, the person in charge of the lab just has the added responsibility of organizing and submitting the lab writeup. In addition to the lab writeup, you give a short, graded demonstration of your working system after handing in your lab report.

Labs are due on the date posted on Canvas. **Late labs will receive a 20 point deduction for each 24 hours they are late.** That means that if you turn it in a minute late, your group will start with a 80% as the highest possible grade.

Lab groups will be assigned at the start of the semester and will remain the same throughout the semester for the labs and final project. If you are experiencing any problems with the dynamics of your group, please let me know early so that we can address them quickly before they get out of hand. Additionally, while typically everyone in a group will receive the same grade on each lab, I reserve the right to deduct points if I feel that someone has not contributed fully to the completion of an assignment.

## Final Project/Challenge

Details on the final project will be given in class. Overall the final project is worth 25% of your grade. The breakdown of the grading for the project is roughly:

| Percentage | Component |
|---|---|
| 5% | Proposal |
| 5% | Checkpoints |
| 5% | Final demonstrations |
| 10% | Project report |

The proposal is a short paper (2-3 page) describing your approach to the final challenge and includes any additional sensors or actuators that you would like to add. There will be checkpoints during the final project as well where you must demonstrate progress. The project report is a final report describing your project and outcome. The presentation and demo will show your robot and algorithms in action to the class and the broader UNL community. The final project report and presentations will occur during the second

to last and final week of class. Further details on the final project will be given in class.

## 439 Versus 839

This course is highly integrated and there are only small differences between the 439 and 839 versions of the course. For 839, the homeworks and labs will have additional questions and parts that are optional for students in 439.

## Grading Scheme

The grading scale for this course is: A 93.00-100%; A- 90.00-92.99%; B+ 87.00-89.99%; B 83.00-86.99%; B- 80.00-82.99%; C+ 77.00-79.99%; C 73.00-76.99%; C- 70.00-72.99%; D+ 67.00-69.99%; D 63.00-66.99%; D- 60.00-62.99%; F 0.00-59.99%. The instructor reserves the right to decrease the thresholds for some letter grades (e.g. make an A- start at 89.1%). A+ is only given in exceptional circumstances.

## School of Computing Policies

Academic honesty is essential to the existence and integrity of an academic institution. The responsibility for maintaining that integrity is shared by all members of the academic community. The University's Student Code of Conduct addresses academic dishonesty. Students who commit acts of academic dishonesty are subject to disciplinary action and are granted due process and the right to appeal any decision.

All students enrolled in any computer science course is bound by the Computer Science and Engineering academic integrity policy:

`http://computing.unl.edu/academic-integrity-policy`

You are expected to read, understand, and follow this policy.

For this course, do not plagiarize (writing or code) and make sure to properly cite any sources you use. Any cheating or plagiarism will be reported to the head of your department and your Dean, and may result in zero credit for that assignment and an F for the course.

Assistance for this course and other School of Computing courses may also be available at the Student Resource Center:

`https://computing.unl.edu/current-undergraduate#SRC`

The School of Computing has an anonymous suggestion box:

`https://computing.unl.edu/anonymous-department-feedback-form`

that you may use to voice your concerns about any problems in the course or department if you do not wish to be identified.

## Instructional Continuity Plans (a.k.a. snow days)

If in-person classes are canceled, you will be notified of the instructional continuity plan for this class by Canvas.

## UNL Course Policies and Resources

Students are responsible for knowing the university policies and resources found on `https://go.unl.edu/coursepolicies`, including:

- University-wide Attendance Policy
- Academic Honesty Policy
- Services for Students with Disabilities

- Mental Health and Well-Being Resources
- Final Exam Schedule
- Fifteenth Week Policy
- Emergency Procedures
- Diversity & Inclusiveness
- Title IX Policy
- Other Relevant University-Wide Policies