

## Cpt\_S 580: Introduction to Robotics, Fall 2017

Dr. Matthew E. Taylor (“Matt” is preferred)

[http://eecs.wsu.edu/~taylorm/17\\_580](http://eecs.wsu.edu/~taylorm/17_580)

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Dana 3, Noon-1:15pm T,Th

Office hours: Scheduled via [meetme.so/taylorm](https://meetme.so/taylorm)

Office: EME 137

TA Name, contact info, office hours, and location:

James Irwin, [james.irwin@wsu.edu](mailto:james.irwin@wsu.edu), hours TBD, Dana 3

Gabriel de la Cruz, [gabriel.delacruz@wsu.edu](mailto:gabriel.delacruz@wsu.edu), hours TBD, Dana 3

Hours Dana 3 lab is open: TBD (*see course webpage*)

Piazza link for discussions: <http://piazza.com/wsu/fall2017/580/home>

Blackboard link for homework & lab submissions: <https://learn.wsu.edu>

This course introduces the basic concepts in robotics from a computer science perspective. Topics include ROS, sensors, actuators, control architectures, kinematics, learning, and human-robot interaction. The focus of the class will be on control of mobile robots and solving artificial intelligence problems. The course will culminate in a team-based, hands-on robotics project. Policies in this syllabus are subject to revision, with notice. Students enrolled in the graduate version of this class will have additional or alternative work, as specified in individual assignments.

### Co-Requisites:

CptS 350 or permission of the instructor

### Credits:

3

### CptS Course Required/Elective:

Selected elective

### Optional Books

- *Introduction to Autonomous Mobile Robots*, Second Edition, 2011. By Siegwart, Nourbakhsh, and Scaramuzza. 0262015358.
- *Programming Robots with ROS: A Practical Introduction to the Robot Operating System*, 2015. By Morgan Quigley, Brian Gerkey, and William D. Smart. 978-1-4493-2389-9



### **Expectations for Student Effort**

- For each hour of lecture equivalent, students should expect to have a minimum of two hours of work outside class. The majority of time spent in the class will be on “labs,” which are small projects that involve programming virtual or physical robots. These may be started in class, but will primarily be worked out outside of class time. Students will also be expected to invest significant effort in the final project, which counts for a large part of the course grade.

### **Required Assignments and Grading Policies**

Late work will be accepted, but the grade will be reduced by 10% for every day that it is late. For example, suppose a lab would be graded as 85/100. If it were handed in 1 hour late, it would receive 75/100. If it were handed in 25 hours late, it would receive 65/100. Work can be submitted up to 7 days late.

A student missing the midterm or final presentation will receive a zero except under exceptional (documented) circumstances.

The course grade (subject to change, with notice) will be based on:

- 10% 2 homeworks
- 45% 6 labs
- 20% 1 midterm
- 25% final project

Attendance is *strongly* encouraged but will not be recorded.

### **Student Learning Outcomes**

- Understanding the major challenge areas in mobile robotics
- Ability to apply basic robotics algorithms to solve fundamental robotics problems
- Ability to apply basic artificial intelligence algorithms to solve path planning and localization problems

### **ABET CptS Criterion 3 Outcomes**

- a) An ability to apply knowledge of computing and mathematics appropriate to the discipline. In particular, students should be able to apply this knowledge in a way that demonstrates comprehension of the tradeoffs involved in the modeling, design and development of software systems of various scales and complexity.
- b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
- c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
- f) An ability to communicate effectively.
- i) An ability to use current techniques, skills, and tools necessary for computing practice.

Student Learning Outcomes for this course: At the end of this course, students should be able to:	Course Topics/Dates The following topic(s)/dates(s) will address this outcome:	Evaluation of Outcome: This outcome will be evaluated primarily by:
Control a multi-wheeled robot using kinematic equations of motion	Kinematics will be taught in weeks 4 and 5.	Additional questions on the kinematics homework will evaluate graduate students' theoretic understanding and additional questions on Lab 3 will evaluate the graduate students' understanding of applying kinematics in practice.
Explain and apply planning algorithms on a virtual robot	Planning will be taught in weeks 6 and 7.	Planning will primarily be evaluated via Midterm #1, including an additional graduate question related to planning, but will also be evaluated in Lab 4, including an additional graduate section of the assignment.
Apply principles of localization and SLAM to a physical robot	Localization will be taught in weeks 9-10, and SLAM will be discussed in weeks 10-11.	Localization and SLAM will be evaluated in LAB 5, which will include an additional graduate section.
Apply optimization or learning principles to a current robotics problem	Optimization and learning will be covered in week 12.	The Optimization and Learning homework will require graduate students to fully set up a novel problem applied to robotics and discuss how it could be solved. One additional graduate-only question will be added to midterm #2.
Develop graduate-level writing and oral presentation skills	This SLO will be addressed throughout the course.	Graduate students will be required to present 1) research papers (week 16) and their novel final project (week 17) in a way understandable to the entire class.
Identify novel research questions related to robotics	This SLO will be addressed throughout the course.	During the final project presentations, graduate students will need to explain open questions related to their project, explain to the class why they would be important to solve, and provide ideas for addressing them.

### Course Schedule (with outcomes) & Assignments

An evolving schedule, along with assignments and lecture slides, may be found on the course webpage. The preliminary schedule is as follows.

Date	Week	Class Topic	Assignment
22-Aug	1	Introduction to class.	Submit introductory survey on Piazza
		Control Architectures: Describe common robot architectures and design considerations	
31-Aug	2	Sensors, Vision: Describe schemes for turning camera output into representations useful for robots. Solve problems related to vision processing	Lab 1: Install ROS on your machine, read through the ROS tutorials, run the example programs, and submit answers to the ROS-related questions
5-Sep	3	Sensors, Other: Describe how distance sensors, including laser and ultrasonic, function and their strengths/weaknesses. Describe how other localization sensors, including GPS, function and their strengths/weaknesses	Lab 2: Install Gazebo and Tuttlebot code on your machine. Control the turtlebot via ROS messages in Python or C++
12-Sep	4	Locomotion: List the main challenges behind different types of locomotion, including walking, rolling, swimming, and flying. Evaluate the usefulness of different locomotion types for a given task.	
		Kinematics: Understand how differential drive robots' wheels interact with idealized ground. Demonstrate understanding by solving kinematic and inverse kinematic problems.	
19-Sep	5	Kinematics, continued: Solve additional problems for different robot platforms, wheel sizes, configurations, and speeds.	Read a provided .pdf on Kinematics. Post at least one question / comment to Piazza
		Manipulation: Describe the different types of actuators and manipulators, as well as their strengths/weaknesses.	
26-Sep	6	Planning: Describe why planning is critical for allowing robots to decide what actions to take in order to achieve a goal. Be able solve depth-first search problems.	Homework 1: Kinematics
3-Oct	7	Planning, continued: Be able to solve breadth-first search and A* search problems. Explain why directed search is preferred to undirected search. List different ways of discretizing a continuous space and the strengths/weaknesses of each.	Lab 3: Control a turtlebot via open loop (e.g., Kinematics) and closed loop (e.g., Vision). Quantitatively compare the two methods
10-Oct	8	Midterm #1: Review	Midterm #1
17-Oct	9	Localization: Solve probability and Bayesian reasoning problems (review). Discuss how sensors and actuators can increase and decreases the probability of the robot's location at different points in the environment. Solve Bayesian updating problems.	Lab 4: Control the physical turtlebot. Explain some of the differences between controlling a robot in simulation and controlling a physical robot.
24-Oct	10	Localization, continued: Describe Kalman and Particle filters. Explain pseudocode for these two methods.	
		SLAM: Solve probability and matrix problems (review).	

31-Oct	11	SLAM: Derive different equations for EKF SLAM. Show SLAM working on a robot. Describe the strengths and weaknesses of EKF SLAM. Summarize differences between EKF SLAM and other SLAM variants.	Lab 5: Run SLAM on a physical turtlebot. Explain the differences between the map generated by the robot and the true map of the lab.
7-Nov	12	Optimization & Learning: List examples where optimization is important in robotics and what techniques are applicable. Define an objective function for a given situation.	Final Project Proposals due. As a group or individual: What can you get done in ~1 month? What technologies will it show off? Will it convince Matt that you learned something in this class? How will Matt assess whether the project succeeds?
14-Nov	13	Human-Robot Interaction: List examples of why HRI is both important and difficult. List some of the open problems in HRI. Given a specific HRI problem, provide possible solution methods.	Homework 2: Optimization and Learning
21-Nov	14	<i>Thanksgiving break</i>	
28-Nov	15	Review	Lab 6: Control and vision in the virtual AR-Drone. Extra credit: also use the physical AR-Drone
5-Dec	16	Presentations by students in class: 1) Discuss one of your current research problems and how you have applied, or could apply, concepts and solution techniques from this class. Or 2) Present the results of a current research paper related to robotics. In both cases, all students should understand why this problem is interesting, useful, and non-trivial.	
11-Dec	17	<i>Final Project Presentations</i>	Present your final project: What was the goal? What was easier than expected and what worked? What was more difficult than expected and what did not work? What would you do differently next time? What would you do if you had an additional month? Show a video or live demo.

### Email

I expect to answer student email within 48 hours, unless it is the weekend. Feel free to ping me if it has been more than two working days and I have not responded. To make sure your mail gets filtered correctly (i.e., gets my attention), please begin emails with a subject of: [CS580]

### Phones/laptops/i-Things during lecture

You may use electronics to take notes and/or look up information in class. However, please make sure your device is silent.

Note that these devices also present temptations that many students find irresistible. You should not use your devices to play games, check Facebook, respond to email, etc., during lecture. Such activities not only distract you, but (more importantly) they may distract others around you.

### **WSU Reasonable Accommodation Statement**

“Students with Disabilities: Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center to schedule an appointment with an Access Advisor. All accommodations **MUST** be approved through the Access Center or Disability Services. For more information contact a Disability Specialist on your home campus.”

### **WSU Academic Integrity Statement**

“Academic integrity is the cornerstone of higher education. As such, all members of the university community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Academic integrity will be strongly enforced in this course. Students who violate WSU’s Academic Integrity Policy (identified in Washington Administrative Code (WAC) 504-26-010(3) and -404) will receive an F in the class, will not have the option to withdraw from the course pending an appeal, and will be reported to the Office of Student Conduct.

Cheating includes, but is not limited to, plagiarism and unauthorized collaboration as defined in the Standards of Conduct for Students, WAC 504-26-010(3). You need to read and understand all of the definitions of cheating: <http://app.leg.wa.gov/WAC/default.aspx?cite=504-26-010>. If you have any questions about what is and is not allowed in this course, you should ask course instructors before proceeding. If you wish to appeal a faculty member's decision relating to academic integrity, please use the form available at [conduct.wsu.edu](http://conduct.wsu.edu).”

### **Safety and Emergency Notification**

“Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the “**Alert, Assess, Act**,” protocol for all types of emergencies and the “**Run, Hide, Fight**” response for an active shooter incident. Remain **ALERT** (through direct observation or emergency notification), **ASSESS** your specific situation, and **ACT** in the most appropriate way to assure your own safety (and the safety of others if you are able).

Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, please view the [FBI’s Run, Hide, Fight video](#) and visit the [WSU safety portal](#).”