# Course EGR 456: Syllabus – Spring 2019
# Robotic Systems II

**Instructor:** Dr. Angela A. Sodemann

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*I most prefer email communication, and almost always respond within 12 hours anytime other than the middle of the night.*

*I also have an ASU email address, but the gmail address given here seems to be more reliable, so I'd prefer if you use this one.*

**Lecture:** T/Th 10:30-11:45am (section 1) and 4:30-5:45pm (section 2) in the robotics studio: Tech 162

**Office Hours:** T/Th 12:45pm-2:45pm
A note about office hours: You are welcome to just drop by my office anytime, but unfortunately the likelihood that I will just happen to be available at any given time is pretty low because I have lots of research projects going on, and I also teach another class. If you can't make it to office hours, the best thing to do is to send me an email to schedule another time to meet.

**Other Ways to Ask Questions:** Every page of our class website has a 'comments' section. Whenever anyone posts in one of these sections, I am notified immediately, and I can post responses. I prefer that you use this way to ask questions anytime you are ok with your question being made public (many times, other students have the same questions you do).

**Text*:*** We have a class website rather than a textbook. The website is www.robogrok.com. I post to this website all lectures, quizzes, review problems, reference material, etc. Access to the website is free.

**Class Materials**: You will need to purchase a robotics parts kit that we will use pretty much daily to practice the concepts we are learning by building robotics components. If you purchased the kit in Robotics 1, you don't need to purchase it again for Robotics 2; it is the same kit.

**Objective**: Students will gain proficiency in intermediate robotics skills and knowledge, including control of manipulator position, velocity, and acceleration, machine vision, artificial intelligence, path-planning, and feedback control.

Course Objectives

1. Students can analyze robotic systems commonly found in industry
2. Students can design and prototype robotic systems of their own invention

Learning Objectives

By the end of this course, students should be able to do the following:

1. Make use of a Spherical Wrist to control the orientation of the end-effector of a 6-DoF serial manipulator
2. Use the Jacobian Matrix to control the velocity and acceleration of the end-effector of any 3-DoF serial manipulator
3. Calculate safe and efficient paths between start and end positions of the end-effector of any 3-DoF serial manipulator, and send commands to the manipulator to follow the calculated paths
4. Explain the operating principles of several user-interface and robot-robot communication devices, and implement the devices to allow real-time communication between robots and human users, and between multiple robots
5. Explain the operating principles of several types of actuators, and implement open-loop and closed-loop position and velocity control with stepper motors
6. Process a video stream to extract information about the robot's environment, and utilize this information in robot decision-making, problem solving, and machine learning
7. Model a feedback motion control system and tune a PID controller using both the time response and the frequency response

Course Topics

- Spherical wrist and orientation control with 6-DoF manipulators
- Denavit-Hartenberg convention for forward kinematics
- Graphical approach to inverse kinematics
- Jacobian matrix for manipulator velocity and acceleration control
- User-interface devices and methods
- Stepper motors and other types of actuators
- Image segmentation and use of features for object identification in machine vision
- Communication between robots, including UART
- Artificial intelligence for searching, problem solving, and machine learning
- Empirical modeling of robot joints for efficient controller tuning

Grading:

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|---|---|
| **Lecture Quizzes:** | **25.5% (1.5% for each of 17)** |
| **Labs:** | **25.5% (1.5% for each of 17)** |
| **Exams:** | **36% (11% each of 3)** |
| **Final Challenges:** | **13% (16% each of 1)** |

Grade Scale:

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|---|---|
| 97-100% | A+ |
| 93-96% | A |
| 90-92% | A- |
| 87-89% | B+ |
| 83-86% | B |
| 80-82% | B- |
| 77-79% | C+ |
| 70-76% | C |
| 60-69% | D |
| <60% | E |

Lecture Videos, Quizzes, and Challenges:
Robotics 2 is a 'flipped class': each class day, you are required to do three things: watch one or more lecture videos, take an online quiz, and complete a hands-on 'Challenge'. The quiz and the challenge are both due at 11:59pm (midnight) on the day indicated by the links on the course website, and will not be accepted late. Lecture videos are for your instruction only and have no grade associated with them.

Each quiz is worth 20 points, and is graded for correctness automatically when it is submitted. When the quiz is submitted, you will be re-routed to a page that gives you a breakdown of which problems you got correct, and some comments to help you figure out what you did wrong for any problems you got incorrect. I encourage you to print on paper, print to pdf, or otherwise save the graded quiz to help you study for the exams.

Lecture videos teach both theoretical concepts and practical skills. Each class day has an associated 'Challenge' to help you practice robotics skills applying your theoretical knowledge. There are two ways to submit a challenge: (1) you can demonstrate the challenge in-person during class or during office hours or (2) you can take a video of your completed challenge, upload your video to YouTube, then and upload a link to your video on the class website. If you use the video submission approach, the link must be submitted by 11:59pm (midnight) on the day indicated by the links on the course website, and will not be accepted late.

Class Time
Since lectures are done by video, class time is free for challenge demonstrations and getting one-on-one help from your instructor and your classmates. You should always try to complete the challenge and the quiz before class; if you have no problems, you are welcome to skip class. If you get stuck on the challenge or want to ask questions, come to class.

Exams:
Each of the three units of the class is paired with an exam that will be taken in class. The exams cover material covered in the lecture videos, the quizzes, and in the challenges, but no 'demonstrations' will be required; the questions will be conceptual. All exams are

closed-note. You may use a calculator and a writing utensil. The class day preceding each exam is a review day. I will give a 'practice exam' ahead of time, which I will solve live in-class on the review day. I HIGHLY encourage you to be in class for review day.

Final Challenge:

A 'Final Challenge' is a project that is defined and guided by information provided by the instructor, with all materials provided. The Final Challenge is not a design project, but a defined 'build' task that requires use of all of the information learned in the class in order to make the project work. At the end of the semester, we will engage in completing a final challenge. This semester, students will be allowed to select which challenge they would like to complete from three options:

(1) **SCARA Writer**: a SCARA-type 3-degree-of-freedom manipulator with a dry-erase marker as an end-effector. Students must build, wire, and program the device to read input from a matrix keypad and, in response, draw one of three shapes on the whiteboard: a circle, a square, or a triangle. This project utilizes students' knowledge of forward and inverse kinematics, the Jacobian matrix, and user-interface.
(2) **Visual Tracker**: a 1 or 2-degree-of-freedom (depending on time restrictions) manipulator with a camera as an end-effector. The visual tracker will be programmed to find a particular object in view, then turn a camera to face the object. The visual tracker will be built with either a stepper motor or a DC motor as the actuator. The visual tracker utilizes students' knowledge of feedback control, position and velocity control of motors, and machine vision.
(3) **Object Sorter**: a device that observes 'example' objects and utilizes machine learning to categorize objects by shape, size, color, or other 'features'. The user will present the object sorter with examples of each of three category of objects (without telling the object sorter what are the categories), then will present the object sorter with a new object. The object sorter will indicate which category the new object belongs to.

*Grading of Final Challenge:*

Guidance for a challenge is divided into a series of 'steps' to be completed. Each step of the challenge is worth an equal portion of the grade. For example, if a challenge is divided into 5 steps, then completion of each step is worth 20% of the grade for that challenge. Rubrics for the final challenges will be provided in Blackboard.

## STUDENTS WITH DISABILITIES

The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. One element of this legislation requires that all qualified students with documented disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation please contact the Disability Resource Center at ASU Polytechnic located in Student Affairs Quad # 4 or call 480-727-1039 / TTY: 480-727-1009. Eligibility and documentation policies are online at: http://www.asu.edu/studentaffairs/ed/drc/

## OTHER ON-CAMPUS RESOURCES

There are lots of valuable resources on campus to help you achieve success both personally and academically. Don't hesitate to use them! A few of these are listed here:

- Writing center – http://www.asu.edu/duas/wcenter
- Learning resources center: http://www.asu.edu/lrc
- Counseling / consultation: http://www.asu.edu/counseling_center/
- Career preparation center: http://www.poly.asu.edu/students/career/

Violations of the University Academic Integrity policy will not be ignored. Penalties include reduced or no credit for submitted work, a failing grade in the class, a note on your official transcript that shows you were punished for cheating, suspension, expulsion and revocation of already awarded degrees. The university requires that should I implement any of these penalties, I must report the matter to the Dean's office. The university academic integrity policy is found at http://www.asu.edu/studentlife/judicial/integrity.html

Cheating is doing something that affects an academic evaluation without the instructor's authorization. You can work together on the homework, but you must turn in your **own** work. You may not work together on exams.

## CLASS POLICY

You must notify an instructor of any inability to take an exam BEFORE the exam; otherwise you will fail the exam, except for a medical emergency. Excused make-up exams will be at our discretion. Late assignments/labs/papers will be assessed a 25% penalty PER DAY (weekend days count). Unless the assignment is a team assignment, you must turn in your own work. Academic dishonesty in any form, including plagiarism, will result in a failing grade.

## YOU ARE EXPECTED TO DO ALL PROJECTS AND HOMEWORK BY YOURSELF UNLESS INSTRUCTED TO WORK IN TEAMS. CHEATING WILL NOT BE TOLERATED. ACADEMIC INTEGRITY

http://www.asu.edu/studentaffairs/studentlife/judicial/academic_integrity.htm

Each student has an obligation to act with honesty and integrity, and to respect the rights of others in carrying out all academic assignments. A student may be found to have violated this obligation and to have engaged in academic dishonesty if during or in connection with any academic evaluation, he or she:

1. Engages in any form of academic deceit;
2. Refers to materials or sources or employs devices (e.g., audio recorders, crib sheets, calculators, solution manuals, or commercial research services) not authorized by the instructor for use during the academic evaluation;

3. Possesses, buys, sells, obtains, or uses, without appropriate authorization, a copy of any materials intended to be used for academic evaluation in advance of its administration;
4. Acts as a substitute for another person in any academic evaluation;
5. Uses a substitute in any academic evaluation;
6. Depends on the aid of others to the extent that the work is not representative of the student's abilities, knowing or having good reason to believe that this aid is not authorized by the instructor.
7. Provides inappropriate aid to another person, knowing or having good reason to believe the aid is not authorized by the instructor;
8. Engages in plagiarism;
9. Permits his or her work to be submitted by another person without the instructor's authorization; or
10. Attempts to influence or change any academic evaluation or record for reasons having no relevance to class achievement.

Following the process defined in the College Policy, **any student who is found to have violated the College's Student Cheating Policy will, as a minimum, receive an E in the course**. The College Policy defines the process to be used if the student wishes to appeal this action.

**APPROPRIATE LANGUAGE**

Engineers, faculty, and students are expected to **effectively** communicate their ideas to their colleagues, students, and instructors. Inappropriate language (written and oral) **does not effectively** communicate the desired ideas to the audience. In any communication you must attempt to understand (be aware of) the other person's (i.e., the audience's) point of view so you can anticipate what might be inappropriate (from the audience's point of view). Inappropriate language not only includes words that are biased or slanted (racially, sexually, ethnically…) but can also include informal (slang) words. In EGR 202 you are expected to use appropriate language in:

1. all your written communications (assignments)
2. all your oral communications (class presentations, conversations with peers or instructors)
3. all your electronic communications (e-mail).

**Use of inappropriate language will result in your withdrawal from the class.**

**APPROPRIATE CLASSROOM BEHAVIOR**

**Cell phones and pagers must be turned off** when you are in the classroom or at least turned to an inaudible ring. If you are expecting a call on your cell phone during class, please do not come to class. If the phone rings audibly, do not answer it in class, but leave the room BEFORE answering. No rollerblades or skateboards are allowed to be ridden or used inside the building. Don't roll into class. Also, no food or drinks are allowed in the room except water, so make sure you eat and drink before you enter.

In class you are expected to participate in the various classroom activities, including:

1. Coming to each class on time with the required materials which **always** include paper and pen/pencil. All students should have paper and pencil in front of them when class begins,
2. Working on whatever assignment has been given, no newspaper, email, texting, etc.
3. Being awake,
4. Following the instructions given by the instructor,
5. Avoiding disruptive side conversations.

**Repeated occurrences of inappropriate classroom behavior will result in a reduction of your grade**.