Course EGR 455 (Undergrad) and EGR 598 (Grad): Robotic Systems I
Syllabus – Fall 2018

1. Contact Information

Instructor: Angela A. Sodemann, PhD

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2. Office Hours

Office Hours: Monday and Wednesday 1:30-4:30

I have many research meetings outside of class and office hours, so it's a good idea to schedule a meeting if you would like to meet outside of class and office hours. To schedule a meeting, email me at my email address given above.

3. Course Objectives and Expected Learning Outcomes

Course Objectives for Undergraduates

1. Students can analyze 3-degree-of-freedom robotic systems commonly found in industry, including manipulator components and types, forward and inverse kinematics, and coordinate transformation.
2. Students are familiar with the terminology and basic concepts fundamental to robotics design, can design appropriate simple robotic systems to accomplish a task in a manner that is effective and safe.
3. Students can distinguish between open-loop and feedback control for velocity and position of a single joint, and can implement feedback for single-joint position control.
4. Students are able to select appropriate sensors, and make use of digital and analog sensors (including visible-light cameras) to obtain and utilize information in a robotic system.

Additional Course Objectives for Graduates

1. Students can analyze 6-degree-of-freedom robotic systems commonly found in industry
2. Students can compute and utilize homogeneous transformation matrices determined using the Denavit-Hartenberg method
3. Students can compute and utilize the Jacobian matrix for velocity control of manipulators
4. Students can independently analyze and communicate analysis of new robotics research and technologies found in the robotics research literature

Course Topics for Undergraduates

- Kinematic Diagrams
- Rotation Matrices
- Displacement Vectors
- Homogeneous Transformation Matrices
- Inverse Kinematics for Position
- Sensors

- Cameras and Color
- Background Subtraction
- Coordinate Transformation
- DC Motors Torque/Speed
- Pulse-Width Modulation
- Open-Loop and Feedback Control
- Step Response
- PID Control

Additional Course Topics for Graduates

- Jacobian Matrices
- Motion Detection
- 3-DoF Camera Transformations
- Frequency Response
- System Modeling from Time or Frequency Response
- Controller Tuning from a Model

4. Grading Policies

Grading for Undergraduates:

Quizzes	**24% (1.5% for each of 16 quizzes)**
Challenges	**24% (1.5% for each of 16 labs)**
Exam 1	**14%**
Exam 2	**14%**
Exam 3	**14%**
Final Challenge	**10%**

Grading for Graduates:

Quizzes	**16% (1% for each of 16 quizzes)**
Challenges	**16% (1% for each of 16 labs)**
White Papers	**12% (4% for each of 3 papers)**
Exam 1	**15%**
Exam 2	**15%**
Exam 3	**15%**
Final Challenge	**11%**

Grading Scale:

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

5. Readings, Assignments, Examinations, Special Materials, Required Activities

How this Class Works:

Each day, you must complete three things: (1) watch the set of videos that are posted on our course website, www.robogrok.com for the day, (2) take the content/theory quiz assigned for the video set, and (3) complete a 'challenge' that involves using the theory of the day to build some device or code. The content/theory quiz is graded for correctness, while the 'challenge' is graded on a complete/incomplete basis. More details on each of these and their absence and make-up policies are included below.

Materials:

There is no textbook required for the class; all material will be provided in video and text form through the class website. However, students must purchase the robotics parts kit from the website, as these parts are used extensively for the hands-on content and deliverables.

Videos:

Each class day has a set of videos which cover both theoretical and applied content which the student is responsible for. The content covers all theory topics necessary to take the content/theory quiz, and also covers the hands-on content necessary to complete the challenge. Thus, watching the videos is intended to be an interactive experience; students should watch the videos with the robotics parts at-hand, and do the activities as they are led by the videos. Some challenges have an additional goal that extends the skills taught in the videos.

There is one set of videos for undergraduates, followed by one or more additional videos for graduate students. Graduate students are expected to work through both the undergraduate videos and the graduate videos, as the graduate videos cover the additional content needed to answer the graduate questions on the quizzes, to complete the graduate deliverables in the challenges, and to answer the graduate questions on the exams.

Content/Theory Quiz:

There are a total of 16 quizzes throughout the semester. Each quiz consists of about 10 questions which are the 'undergraduate questions' and an additional 1-5 questions which are the 'graduate questions'. Undergraduate students only need to answer the undergraduate questions, and will be graded only on their answers to the undergraduate questions. Graduate students need to answer BOTH the undergraduate questions AND the graduate questions, and will be graded on their answers to both. Each quiz is worth 1.5% of the total grade for undergraduates and 1% for graduates. Each quiz is taken online, and is due by midnight on the day listed in the schedule unless an extension is granted. See the section 'Extensions' in Part 6: Absence and Make-Up Policies. If a quiz is completed after the due date, factoring in extensions, it will be graded and feedback will be given, but it will not be awarded any points. Quizzes may be taken and submitted as many times as the student would like, and all submissions will be graded and feedback given. However, only the grade on the first submission will be recorded as the student's official grade for the quiz.

Challenges:

There are a total of 16 hands-on activities known as 'challenges' through the semester. Each challenge is designed to allow students to practice application of the theoretical concepts learned in the content videos. Each challenge is graded on a pass/fail basis by completion. In each content section of the class, there is a list of requirements for completing the challenge. There are two lists of requirements: one for undergraduates, and one for graduates. Graduate students must meet both lists of requirements in order to pass the challenge. There are two ways to complete a challenge: (1) demonstrate the working challenge in-person during class or during office hours or (2) make a video of the working challenge and submit it via the class website. Students who submit challenges by video will be notified via email whether their challenge submission has passed or failed. If a student fails a challenge, they may fix their challenge and re-submit up until the deadline, factoring in extensions. Each challenge is due by midnight on the day of the deadline, factoring in extensions. See the 'Extensions' section below.

Final Challenge:

During the course of the semester, students will be learning all of the topics necessary to build and program a pick-and-place manipulator. For this challenge, students will work individually to build a working pick-and-place manipulator from parts in their robotics kit. The manipulator will do the following: (1) use a webcam and Python program using OpenCV to determine the location of a small nut placed within the manipulator's workspace, (2) move the end-effector of the manipulator to the location using a PSoC program, (3) pick up the object using the electromagnet attached to the end-effector, (4) move the end-effector to a specified drop-off location, and (5) release the nut by turning off the electromagnet.

Students will have a minimum of 2 and maximum of 4 in-class days to work on the challenge and get assistance from the instructor, but they are also allowed and expected to work outside of class. Students will demonstrate their robot either during the last day of classes or during the week of final exams. Final Challenges will be graded on how well the robot works, according to a score sheet to be distributed around the time of Exam 3 (just prior to the allotted Final Challenge Workdays).

Final Challenge for Graduates:

Graduate students have three additional requirements for the Final Challenge, which reflect the additional theoretical content learned during the class: (1) they must show the final homogeneous transformation matrix for the manipulator built, using the Denavit-Hartenberg convention, (2) the velocity of the end-effector must be controlled using the Jacobian matrix, and (3) they must use PID control to position the rack and pinion device, and show how they have determined the PID gains from a model of the device.

White Papers (for Graduates Only):

Three times throughout the semester, corresponding with the three exam times, graduate students must select a current robotics research topic and report on the topic. To accomplish this, each graduate student will perform a preliminary literature search on the topic, selecting a minimum of five papers. Students will then write a paper covering at least the following:

(1) An explanation of the overall problem the researchers are addressing. This explanation should include both the technical explanation of the problem, as well as a high-level or 'real-world' description of the significance of the problem.

(2) A comparison of the approaches taken by the different studies reviewed.
(3) A conclusion summarizing the state-of-the-art: how successful or unsuccessful were the reviewed research studies at solving the problem, and what aspects of the problem remain to be solved?

Each of the three white papers should be no less than 2 and no more than 4 single-spaced pages. Each paper should cover a different topic. The papers reviewed must be cited in IEEE format.

Exams:

There are three exams throughout the semester, one exam for each of the three main topics covered: (1) kinematics, (2) sensors and vision, and (3) motion control. Each exam is an on-paper exam taken in-class. The exams for graduate students will include additional questions covering the additional theoretical content which they cover.

Final Exam:

There is no final exam. The final exam day is used for Final Challenge demonstrations.

6. Absence & Make-Up Policies

Extensions

If a student cannot complete the quiz or challenge by the original posted deadline, the student is allowed to request an 'extension'. An extension gives a student 3 extra days to complete both of the deliverables of the day (the theory quiz and the challenge). Each student is allotted 5 extensions for the semester. Each student may distribute the 5 extensions however they would like – more than 1 extension may be used on a single deliverable for more days to complete the assignments, or they may be used on separate assignments. Quizzes and Challenges submitted after the deadline, factoring in extensions, will be graded and returned to students for feedback and learning purposes, but will not be accepted for credit.

Extensions do not apply to exams, white papers, or the final challenge. If a student requires an extension on one of these deliverables, they must contact me.

Accommodations will be made for religious observances provided that students notify the instructor at the beginning of the semester concerning those dates. Students who expect to miss class due to officially university-sanctioned activities should inform the instructor early in the semester. Alternative arrangements will generally be made for any examinations and other graded in-class work affected by such absences. The preceding policies are based on ACD 304–04, "Accommodation for Religious Practices" and ACD 304–02, "Missed Classes Due to University-Sanctioned Activities."

7. Classroom Behavior

The use of recording devices is not permitted during class. Any violent or threatening conduct by an ASU student in this class will be reported to the ASU Police Department and the Office of the Dean of Students.

8. Academic Integrity

All students in this class are subject to ASU's Academic Integrity Policy (available at http://provost.asu.edu/academicintegrity) and should acquaint themselves with its content and requirements, including a strict prohibition against plagiarism. All violations will be reported to the Dean's office, who maintain records of all offenses. Students are expected to abide by the FSE Honor Code (http://engineering.asu.edu/integrity/).

9. Disability Accommodations.

Suitable accommodations will be made for students having disabilities and students should notify the instructor as early as possible if they will require same. Such students must be registered with the Disability Resource Center and provide documentation to that effect.

11. Sexual Discrimination

Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at https://sexualviolenceprevention.asu.edu/faqs.

As a mandated reporter, I am obligated to report any information I become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling, is available if you wish discuss any concerns confidentially and privately.

Any information in this syllabus (other than grading and absence policies) may be subject to change with reasonable advance notice.