RBE 1001: Introduction to Robotics
C-Term 2019-20
Syllabus

Last modification: January 13, 2020

General Information

Instructor	Greg Lewin	glewin@wpi.edu
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Lab Manager	Kevin Harrington	harrington@wpi.edu
Lectures	MTRF 12pm-12.50pm	SL411
Lab	W 8am-9.50am	FI103
	W 10am-11.50am	FI103
Office hours	See calendar on canvas home page	

Course Description

In this introductory course, the student will explore concepts from the foundational robotics disciplines – mechanical engineering, electrical and computer engineering, and computer science – and, more importantly, apply them to the design and construction of robots.

Technical topics include static force analysis, power transmission and elements of mechanisms, pneumatics, DC motors, fundamentals of electronics, control systems, sensor performance and integration, and embedded programming.

Building a robot, however, requires more than mastering the technical topics, and attention will be given to robot design and integration, including identifying functionality, evaluating options and trade-offs, and testing.

Learning and assessment methods will include self-directed research, individual graded homework, quizzes, and team lab assignments and projects. Laboratory sessions will include hands-on applications of technical topics as well as integrative challenges, culminating in a mobile robot for a complex end-of-term challenge.

Objectives

The successful student will be able to:

- Demonstrate a deliberate design process, broadly including:
  - The ability to formulate a problem,
  - The ability to identify options and implement relevant solutions,
  - The ability to evaluate those solutions, and
  - The ability to justify design decisions through objective criteria.
- Identify important subsystems and integrate them into a working robot.
- Demonstrate fundamental technical competency in the disciplines that robotics is built upon, including:
  - Design, build, and analyze basic electronic circuits,
  - Apply static analysis and testing to assess robot performance,
  - Write computer programs to perform important tasks, including interfacing with sensors and actuators and controlling a robot.
- Demonstrate prototyping and building skills.
- Demonstrate effective teamwork and communication skills.

Expected Background

The student should have a solid background in computer programming – at least one course that involved writing computer code. The working language of the course – and much of robotics – is `C++`, though it is not expected that you have direct experience in that language. Tutorials on syntax and program structure in `C++` will be provided.

The student should have a solid grasp of introductory physics, including the concepts of forces and moments and work and power. Introductory material will be provided for review, but the course will begin with the *application* of physics principles.

Course Administrative

I will post all assignments, quizzes, pre-labs, etc. on canvas. *I will also post all class prep as "zero point" assignments so that you know what to do to prep for each class*. I reserve the right to hold pop quizzes to ensure that you are properly preparing for class. I will also use the Announcement function of canvas for routing administrative tasks – it's not ideal, but it beats taking up valuable lecture time with mundane announcements.

References and Materials

You do not need to purchase a textbook for this class, as (almost) **all materials will be provided online** (mostly through the Gordon Library). Resources are provided for both technical concepts and robotic applications. The discipline-specific references will be repeated in the coming assignments, with direction for which parts to read, but are provided here for completeness.

You will need to acquire a Homework Kit, available at the bookstore, that contains a microcontroller (the `ESP32` Dev Board) and several sensors and other components.

Programming

- *Programming in C++ for Engineering and Science* by Larry Nyhoff. It is available Available online through Gordon Library.

Mechanics

- *Statics For Dummies*[1] by James Allen. Available online through the Gordon Library.
- *Statics, Learning from Engineering Examples* by Igor Emri and Arkady Voloshin. Available online through the Gordon Library.

Electronics

- *Understanding Circuits: Learning Problem Solving Using Circuit Analysis* by Khalid Sayood (1st ed). A good option if you've seen circuits before but need a refresher. Available online through the Gordon Library.
- *Introduction to Circuit Analysis and Design* by Tildon H. Glisson (1st ed). A very thorough look at circuits, great for anyone who needs to know why things work the way they do. Available online through the Gordon Library.
- *College Physics* by OSC Rice University.
- *Introduction to Electrical Circuit Analysis* by Ozgur Ergul. Available online through the Gordon Library.
- (Advanced Mathematics) *Introduction to Linear Circuit Analysis and Modelling : From DC to RF* by Luis Miguel da Silva Carvalho de Moura and Izzat Darwazeh. Available online through the Gordon Library.

Robotics and Mechatronics

- *Introduction to Mechatronic Design*, J. E. Carryer, M. Ohline, and T. Kenny, Pearson, 2011. A great reference for everything mechatronics, including some chapters on system integration. On reserve at Gordon Library and there should be a copy in the Robotics Lab.

[1] I really, really don't like the title and its implications...but it's a well written guide to statics!

- The Robotics Primer, Mataric M.J., The MIT Press, 2007. An excellent, high-level overview of robotics.

Advanced Robotics texts

- *Springer Handbook of Robotics*, by B. Siciliano and O. Khatib (Eds.), Springer, 2008. Available online through the Gordon Library.
- *Introduction to Autonomous Mobile Robots*, by R. Siegwart, I. R. Nourbakhsh, MIT Press, 2011. Available online through the Gordon Library.
- *Robotics, Vision and Control*, by P. Corke, Springer, 2011. Available online through the Gordon Library.

Assignments and Grading

This being WPI, you will be evaluated on both theoretical and practical knowledge. Your knowledge of theory will be assessed through "traditional" methods, such as homework and quizzes. Your practical knowledge will be assessed through lab exercises, challenges, design reviews, and the performance of your final robotic system.

Theory	Weight
Homework	5%
(5) Weekly quizzes	20%
Final	25%

Practice	Weight
Pre-/post-lab exercises	10%
Delivered systems	20%
Design reviews (incl. final report)	20%

Homework: Homework will be assigned regularly throughout the term. All homework will have a due date; late homework will be penalized 25% for each day late. Not all homework problems will be graded – we may select a subset from any given assignment – but solutions to all of the problems will be provided. Your solutions must be neatly hand-written or typed; in the case of code, guidelines for submissions are provided in the first coding assignment. **Code that does not compile as submitted will receive an automatic zero.** When doing homework, you may discuss principles and methods with your classmates, but the work you submit must be your own. A good rule-of-thumb is: when you're writing your solutions or code, you are sitting on your own. There will be several assignments where you will have to do research on topics that are not presented in class (for example, basic programming tutorials). These assignments are designed to build your base knowledge so that lectures will be more productive. You are encouraged to seek out course staff (the instructor, TAs, SAs) where you need assistance in these exercises.

Quizzes: There will be weekly, online quizzes, due Friday evenings (but not the first Friday). Quizzes are open book/open notes, but you may not use any online resources and you may not use engineering apps unless otherwise directed (for example, you may not use resistor value calculators where you type in the color bands).

Final Exam: There will be a final exam in the last week of the term.

Laboratories: Students are required to attend all of their scheduled lab sections and must complete all the lab activities. Lab grades will be based on assignments, reports, and performance in the lab. Pre-lab assignments are due at the beginning of each lab session and are typically graded on an individual basis. Post-lab assignments will have the due date on them and are typically team assignments. You must obtain sign-offs for all indicated lab exercises to receive credit for the lab. Though the lab handouts have blanks for signatures, sign-offs will be done electronically. You may receive sign-offs from the instructor, teaching assistants, or student assistants.

Delivered Systems: Your team will build/modify a robot to complete a final demonstration project, described elsewhere. You will also have smaller hands-on projects designed to focus on one topic or another. You will be graded on the performance of these systems, including "fit and finish." Details for each project will be provided elsewhere.

Design reviews and reports Throughout the term, you will attend design reviews with course staff and, at times, other students. These reviews are meant to move you forward in the project and give you feedback on your ideas and implementation. You will not only be graded on the performance of your robot, but **significant weight will be given to your design process**. In short, your goal is to justify your decisions and demonstrate that you built the best robot you could reasonably build. More direction on design reviews, and what constitutes a good design process will be presented throughout the term.

Course Calendar

The course calendar is provided separately, as it may be adjusted throughout the term, as needed.

Course Policies

Student Disability Services: If you need course adaptations or accommodations because of a disability, or if you have medical information to share with the instructor, please make an appointment with your instructor within the first week of classes. Students who believe that they may need accommodations in this class are encouraged to contact the Disability Services Office (DSO) as soon as possible to ensure that such accommodations are implemented in a timely fashion. The DSO is located in Daniels Hall, (508) 831-5235. More information can be found at: https://www.wpi.edu/student-experience/resources/disability-services

Academic Honesty: Any work you present as your own should represent your own understanding of the material. When external sources were used as significant points of information (sample code, etc.), the source must referenced in your submission. Review the Academic Honesty Policies at: http://www.wpi.edu/Pubs/Policies/Honesty/policy.html.