Worcester Polytechnic Institute

RBE 594 – CAPSTONE EXPERIENCE IN ROBOTICS ENGINEERING
Department of Robotics Engineering
Fall 2022

COURSE AT A GLANCE

Instructor	Loris Fichera, PhD lfichera@wpi.edu Room 4808, 50 Prescott https://www.wpi.edu/~lfichera
Lectures	Fri 3:00-5:50 pm Kaven Hall (KH) 116
Office hours	TBA
Course URL	https://canvas.wpi.edu/courses/38111
Recommended Readings	F. J. Looft, Systems Engineering for Capstone Projects - A Practical Guide for Applying SE Methods to Capstone Projects, 2018. *(Available as PDF on the Canvas site.)*

Welcome to RBE 594! This project-based course integrates robotics engineering theory and practice and provides the opportunity to apply the skills and knowledge acquired in the RBE curriculum. The project is normally conducted in teams of two to four students. Students are encouraged to select projects with practical significance to their current and future professional responsibilities. The projects are administered, advised, and evaluated by WPI faculty as part of the learning experience, but students are also encouraged to seek mentorship from experienced colleagues in the Robotics Engineering profession.

Prerequisites: Since the Capstone Project will draw on knowledge obtained throughout the degree program, it is expected that students will have completed most or all of the coursework within their plan of study before undertaking the capstone project.

About the instructor: Dr. Fichera is an Assistant Professor of Robotics Engineering, with courtesy appointments in Computer Science and Biomedical Engineering. His research interests are in medical robotics, and image-guided surgery. An alumnus of the Italian Institute of Technology (PhD, 2015), he was a postdoc at Vanderbilt University before joining WPI in 2017. He leads the Cognitive Medical Technology (COMET) Laboratory, located at 50 Prescott, suite 4832.

The instructor reserves the right to modify the course outline and policies mentioned in this syllabus at any time during the term.

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LEARNING OUTCOMES

By the end of this course, students will be able to:

1. Create an engineering solution to a challenging real-world problem
2. Generate a work plan that considers existing constraints and available resources
3. Disseminate results to domain experts and members of the general public

COURSE LOGISTICS

- **Course Format:** Classroom sessions will be held in person.
- **COVID-19 Accommodations:** If you need course accommodations because of a COVID-19-related matter (including, but not limited to, the need to isolate/quarantine, caring for a loved one, etc.), you should inform the instructor as soon as possible.
- **Projects**: Students (in consultation with the faculty instructor) are responsible for generating project ideas. To facilitate this activity, the first few weeks of the semester are structured to generate ideas, create teams, and get projects started. Single-student projects are discouraged and will only be considered on a case-by-case basis.
- **Classroom sessions**: It is not unusual for capstone project courses to meet formally *every other week* to allow time for progress on the individual projects and allow time for individual advisor/team meetings. This alternate week schedule is reflected in the detailed schedule at the end of the document.
- **Out-of-class communication**: A course channel will be set up by the instructor on Microsoft Teams. This channel will have to be used for all teams-instructor communication and to keep track of all the material generated in the project.
- **Student Accessibility Services:** If you need course accommodations because of a disability, or if you have medical information to share with the instructor, you must inform your instructor within the first week of classes. If you have not already done so, students with disabilities, who believe that they may need accommodations in this class, should contact the Office of Accessibility Services (OAS), as soon as possible to ensure that such accommodations are implemented in a timely fashion. More information: https://www.wpi.edu/offices/office-accessibility-services

EXPECTATIONS

- **A well-written project proposal is due at the end of the second week of the course.** The proposal must explain (1) what the problem being addressed is, (2) why it is important, and (3) outline a method to solve it. The proposal should also include a tentative timeline with milestones and deliverables.
- **Literature search.** You should research relevant literature and explore whether others have solved similar problems in the past – and if so, what approaches have been used. A critical review of the work of others must be included in the proposal, explaining if any

existing approach/method can be used, even partially, in the resolution of the problem at hand. The library is an invaluable resource – *see the note at the end of this document for library resources*.

- **The project must represent a significant effort.** You should put an average of 15--20 hours per week into the project. Thus, a team of 4 should give evidence of 60—80 person-hours of work every week. This evidence includes submission of written reports (see below) and any other deliverables created by the team.
- **Project review meetings will be held in class every week.** If you will be unable to attend a scheduled meeting, call or email ahead of time.
- **Written progress reports will have to be shared with the instructor at least two days prior to the weekly meeting.** The weekly progress report can be short -- 1 or 2 pages with bullet points and/or figures/videos -- but must state what has been accomplished since the last report, what is expected to be accomplished in the next project interval, and what obstacles were encountered. The end of term/semester summary, project proposal, or final report may replace the weekly progress report.
- **Project deliverables:**
  - **Final Report:**
    i. **A well-written final report is required.** Since this is a graduate course, and one of the last taken in the MS program, all submitted written work is expected to be impeccable. Contact the Writing Center at WPI if assistance is needed with writing style, formatting, etc. - *contacts are listed at the end of this syllabus.*

    ii. **The report should be formatted using the IEEE double-column conference template.** At a minimum, it should contain the following sections: introduction, materials and methods, experiments, results, discussion.

    iii. **Figures in the report must be of high quality.** Use vector graphics as much as possible. Bitmaps should be at least 300 DPI. Plots should have clearly legible labels and legends.

    iv. **A complete draft of the final report must be submitted at least 10 days before the final deadline.** Expect revisions. Submitting sections earlier is encouraged. Give the instructor at least 10 days to review submitted materials.

    v. **Start writing your final report as early as possible and make additions/revisions consistently over the entire project period.** Drafting the first version of the final project report two weeks before the end of the semester is a no-starter. Start writing early – ideally, start writing on day one! Do not aim for perfection right away – just focus on generating sections. You will have time for editing/revisions later in the project. Generating good technical written materials takes time and is one of the fundamental skills for any engineer. It only gets better with practice.

- **Final Presentation and Demo:**
  i. **A well-organized final presentation is required at the end of the project.** This will be done during the last lecture day of the semester.
  ii. **Use professional tools for your presentation**. You are recommended to use PowerPoint for presentations and Adobe InDesign for poster preparation. The instructor will provide samples upon request. Expect to go through a dry run of the presentation with the instructor.
  iii. **A final demo of the robot should be performed.** *Warning: Normally well-behaved demos have been known to break in the presence of a project advisor! Make a video as a fail-safe option.*
- **Software and Hardware:**
  i. **All software must be of professional quality.** It is okay to rapidly prototype software, but keep in mind that "temporary" fixes tend to become permanent very quickly.
  ii. **Software must be thoroughly documented and debugged.** Include a User's Manual, if appropriate (e.g., through Gitbook).
  iii. **Maintain an up-to-date project repository with all relevant code.** Include a README file with a description of the project on how to run the software. In your repository structure, include directories for the proposal, specs, weekly reports, and code. The project advisors will specify where your repository documents should be maintained (GitHub or Dropbox).
  iv. **Hardware built during the project must be of professional quality.** Several machine shops and 3D printers are available on campus to build/3D-print parts. These resources may be busy during the school year, so if want to use them, plan early. Alternatively, you may consider using external vendors like Protolabs.
  v. **You must keep track of CAD models, PCB designs, etc. generated during the project.**

- **Academic honesty is critical to all project work for RBE 594 students.**
  - All submitted work, regardless of its type (written or oral reports, detailed designs, analysis, drawings, etc.) is expected to be the work of the submitting student or student team.
  - Any work that is submitted that is not student work must be properly attributed. This includes designs, images, written work, ideas, and any other material that is not the work of a student/team.
  - Academic misconduct will not be tolerated. Review WPI's Academic Integrity Policies at: https://www.wpi.edu/about/policies/academic-integrity
- **All deadlines for submitted work will be firm. Late work will be accepted with a grade penalty.**

- **Attendance in all classroom sessions is mandatory.**
  - If a student needs to miss class, then that information should be conveyed to the class instructors ahead of time, not after the missed class.
  - Team members must be informed if a team member will be missing a class.
  - If the instructor has to cancel class, an email will be sent to all class members.

GRADING RUBRIC

Projects will be graded based on the following criteria:

A: This grade denotes **excellent work** that attains all of the project goals and learning outcomes. The product and process of this work meet all of the expectations and exceed them in several areas, such as particularly effective or creative goals and/or methodologies, initiative, originality, depth and critical thought in analysis and recommendations. Students take the lead in discussions and analysis rather than just responding to faculty suggestions (particularly as the project matures). Teamwork self-assessment shows critical thought, professional and personal development, and tangible evidence of learning. Any individual earning an A will have been assessed positively by his or her team members, with tangible and appropriate evidence to support the assessment.

B: This grade denotes **consistently good work** that attains the project goals and learning outcomes. The product and process of this work meet but generally do not exceed all of the expectations. Characteristics of B work include: following up on advisor suggestions; defining a clear goal and objectives; writing a clear, professionally presented report with good and improving drafts along the way; completing all work in a timely and satisfactory manner; demonstrating sound analysis that includes logical interpretation of findings; delivering useful recommendations; coming to meetings well prepared, and working hard, consistently, and diligently. A B grade means the team did a good, strong job, but perhaps did not show lots of initiative, originality, or critical thinking in a self-directing and proactive manner. Teamwork self-assessment shows critical thought, professional and personal development, and tangible evidence of learning. Any individual earning a B will have contributed consistently to the team effort, with tangible and appropriate evidence to support that assessment.

C: This grade denotes **acceptable work** that partially attains project goals and learning outcomes. The product and process of this work meet some but not all expectations. Characteristics of C work include meeting some but not all requirements for a B grade; writing that is readable but didn't show much progress between drafts and required lots of faculty input; weaknesses in methodology and analysis that could have been anticipated and addressed and demonstrating little or no originality and initiative. Missing deadlines, missing meetings without prior notification, and lack of response to faculty comments on report drafts are traits common to C-

level performance. The teamwork self-assessment may show little evidence of critical introspection or learning about teamwork, or avoidance of conflict. An individual may earn a C, even if the project as a whole is evaluated more positively, if his or her contribution is sub-par, with tangible and appropriate evidence to support the assessment.

D: This grade denotes work that is **unacceptable for graduate credit**. Characteristics of D work include doing very little throughout the project; missing several meetings without prior notification; coming unprepared to meetings or having little to show; repeatedly missing deadlines; turning in substandard work; not completing assigned tasks and showing little or no initiative and originality.

F: This grade denotes **unacceptable work**. It means that a student's performance (or lack of it) has seriously impeded group progress, or it has embarrassed the group, the project sponsor, or WPI.

COURSE SCHEDULE (TENTATIVE)

Mtg.	Date	What we will do	What is due
1	Aug 26	• Introductions, class discussion, format, expectations, etc. • Presentation of project ideas • Teaming	• come to class ready to propose ideas for a project that requires a 3-4 people team • 1 slide introducing yourself (with a selfie), your background, outside interests, project interests (etc.) • 1 slide for each project idea
2	Sep 2	**No Class -** *Individual project team meetings*	
3	Sep 9	• Detailed progress reports • Team project presentations • Class critique of presentations/ideas	2-page detailed project statement with proposed methods and desired outcomes
4	Sep 16	**No Class –** *Individual project team meetings*	
-	Sep 23	**No Class –** *Wellness Day*	
5	Sep 30	• Detailed progress reports	Introduction (§1), *revised* project statement (§3), key references (Bibliography)
6	Oct 7	**No Class –** *Individual project team meetings*	

7	Oct 13	• Detailed progress reports	*Revised* introduction (§1), draft background (§2), revised project statement (§3), bibliography
8	Oct 28	**No Class –** *Individual project team meetings*	
9	Nov 4	**No Class –** *Individual project team meetings*	
10	Nov 11	• Detailed progress reports	Updated (§1-§3), draft §4 Results
11	Nov 18	**No Class –** *Individual project team meetings*	
-	Nov 25	**No Class –** *Thanksgiving Break*	
12	Dec 2	• Detailed progress reports	Updated (§1-§4), draft (§5) Summary and Conclusions
13	Dec 9	• **No Class –** *Individual project team meetings* • Practice Final Presentations	
14	Dec 16	• **FINAL PRESENTATIONS** (20 min/team)	**FINAL REPORT**

DEPARTMENT OF ROBOTICS ENGINEERING – STUDENT OUTCOMES

Each of the Course Learning Outcomes (LOs) listed on page 2 of this syllabus addresses one or more of the RBE Department Student Outcomes (SOs) listed below:

- SO #1: Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- SO #2: Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- SO #3: Communicate effectively with a range of audiences
- SO #4: Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- SO #5: Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- SO #6: Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

- SO #7: Acquire and apply new knowledge as needed, using appropriate learning strategies
- SO #8: Evaluate and integrate the mechanical, electrical, and computational components of a cyber-physical system
- SO #9: Recognize and take advantage of entrepreneurial opportunities

Our Course LOs relates to RBE Department SOs according to the following table:

		RBE Department Student Outcomes (SOs)									**Measured by**				
		SO #1	**SO #2**	**SO #3**	**SO #4**	**SO #5**	**SO #6**	**SO #7**	**SO #8**	**SO #9**	HWs	Exams	Labs	Proj	Others (Specify)
Course Learning Outcomes (LOs)	**LO #1**	**X**	**X**		**X**	**X**	**X**	**X**	**X**	**X**				**X**	
	LO #2					**X**								**X**	
	LO #3			**X**										**X**	