EECS C106A/C206A / BIOE C106A

Final Project Guidelines

Fall 2019

Overview & Requirements

Your final projects must include **sensing**, **planning**, and **actuation**, which means you must be performing a real robotic task, on real hardware, using real sensors. Beyond requiring these three elements, the project is completely open-ended; we have included some examples and ideas at the end of this document to help you get started.

Dates, Deadlines, & Grading Breakdown

Mini-Proposal	10/10	5%
Final Proposal & Parts List	10/26	10%
Final Products		
Presentation	12/12, 12/13	20%
Demo	12/12, 12/13	20%
Report (website)	12/20	20%
Video	12/20	20%
Lab Cleanup	12/20	5%

Grading Scheme

Overall, we will be evaluating your project on its complexity, polish, the participation of all team members, and on the following characteristics:

- **Design**: How original or ingenious is your design?
- **Implementation**: Does your implementation work? How reliable is it?
- **Scope**: Does your project contain sensing, planning, and actuation?
- **Rigor**: Do you properly test/evaluate your project? Are your assumptions reasonable?

These characteristics will be evaluated on the following scale:

Mark	**Description**	**Equiv. Score** (undergraduate)	**Equiv. Score** (graduate)
5	Exceeds expectations	95-100%	90-100%
4	Fully meets expectations	90-95%	80-90%
3	Adequately meets expectations	80-90%	70-80%
2	Barely meets expectations	70-80%	60-70%
1	Does not meet expectations	0-70%	0-60%

We expect most projects to score around 3-4 in each category, but we are not opposed to giving everyone a 5 if all projects are great. **Note that you do not need all 5s to make an A on the project.**

Projects will vary in complexity, and in general, the more complex or risky the project, the less polished we expect it to be. In other words, if your project is very complex, then we don't expect it to work perfectly or reliably. If your project is relatively simple, however, we'll expect it to work reliably and consistently, as you'll have more time to devote to getting it working well. A project that is simple but well done (i.e., very reliable) may receive the same grade as a high-risk project that is functional.

Late Work Policy

In general, **no late project work will be accepted**. If you feel that you will be unable to make any of the deadlines listed above, let us know **before** the deadline explaining your situation and we will revisit this policy at our discretion.

Groups

Project groups should consist of **4-5 people**. If you would like to form a group that is larger or smaller, please talk to us **before** submitting your mini-proposal. In particular, smaller groups will likely only be considered if they don't use lab materials. Note that expectations will scale with the number of project group members: we will expect more polish, complexity, and reliability from larger teams. We will also of course expect that all members equally contribute to each team.

If you're having trouble finding a team, feel free to start a thread on Piazza!

Multi-Class Projects

If you are in another project course, you are welcome to complete a single project for both classes, provided the scope of the project is extended appropriately (i.e., you should not simply turn in the same project for both classes — the portion of the project that you turn in for EE106A should stand on its own). You may work with team members who are only enrolled in the other class, as long as you complete all the project requirements of EE106A as listed here. We may ask to see the report you submit to any other class to ensure that the amount of work completed is sufficient to cover both assignments.

Mini-Proposal (due 10/10)

A preliminary mini-proposal is due **10/10** at **11:59p** and should be submitted to Gradescope. This document should be about one page and contain the following:

- name and contact information of each team member (full name, SID, email address);
- (brief) qualifications of each group member (department, previous experience, etc.); and
- project idea(s) and a brief description thereof.

In the subsequent week, we will read over your mini-proposals, and the week of 10/21, we will meet with each group individually to discuss your ideas in lieu of regular lab section (information forthcoming).

Final Proposal & Parts List (due 10/26)

Incorporating your project meeting feedback, you will complete a finalized proposal, due **10/26** at **11:59p** to Gradescope. A LaTeX template for this proposal has been provided on the website; you are not obligated to use the template, but all listed components should be present and complete.

An important part of this final proposal is the **parts list**, or **bill of materials**. Each group will be allocated approximately $50 to spend on parts for their project. You are not obligated to use these funds (you may complete the project using only existing lab hardware), and all purchased components must be returned to the lab on completion of the project. **If you plan on requesting materials, it's critical that they appear clearly and completely in your final project proposal, as that gives us plenty of time to order them for you in time for subsequent project deadlines.**

Final Demo / Presentation (12/12, 12/13)

Final project demonstrations will occur in the lab on **12/12** and **12/13** (the Thursday and Friday of RRR week), time TBD. We expect that **all team members are present** for the demos, so if you have a conflict, let us know ASAP and we will do our best to accommodate you as we develop the final schedule. Exact expectations will be posted to the website.

Final Project Report (due 12/20)

Final project reports are due **12/20** at **11:59p**, and will take the form of a website. It will also include link(s) to the video(s) of your functional system that make up 20% of your final grade. Exact expectations will be posted to bCourses.

Teamwork / Peer Grading

To help ensure fair project grades, final scores will be modified based on peer evaluation. Each student will fill out a form evaluating both their own and teammates' performances. Exact instructions will be posted to bCourses.

Cleanup

The final 5% of your project grade will come from cleaning up your lab space and returning all project hardware; this must be completed by **12/20**. All laboratory space should look the way it did at the start of the semester. We will provide boxes and instructions as the date nears.

Example Projects & Ideas

A list of past projects has been posted to the website. The teaching staff has collated a number of research projects for groups to attempt. If you're interested in getting involved in undergrad robotics research or start involvement with another lab, this is a great way to get your foot in the door. We've also provided a couple more general ideas.

Research Projects

If you're interested in a research project, express interest to Valmik/Isabella and state your interest in your mini-proposal. However, please also provide a backup project, since most of these projects can only support one group, and we want to ensure a good fit between you and your sponsor.

- MRI-compatible XY gantry with impedance control.
  Sponsor: Zoe Cohen, HART Lab
  Zoe needs an XY gantry for human motion studies in MRI. The device needs to be MRI-compatible, and human-safe, so ideally you'd be implementing an impedance controller (combination of position/force control). If you're interested, you should start pretty early (design and build will take a while).
  Skills needed: Mechanical design, mechatronics, control.

- Stewart Platform build
  Sponsor: Sarah Seko, HART Lab, Robert Matthew, UCSF
  In this project we aim to assess the efficacy of a Stewart platform type robot for guided movement exercises. Stewart platforms are usually used to make flight simulators (see page 138-139 in MLS) and have had some success in ankle therapy. The goal of this project is to design, build, and test a benchtop Stewart platform for use in a clinical setting. After building a system to control the position and orientation of a limb in 6DoF, you will implement an admittance controller to allow the system to move based on the applied forces. If you're interested, you should start pretty early (design and build

will take a while).
Skills needed: Mechanical design, mechatronics.

- Blind Insertion with a Soft Tactile Sensor
  Sponsor: Isabella Huang, HART Lab
  Human hands have extremely high-resolution tactile sensing capabilities. Without vision, we can sense not only the shapes of the objects we are touching, but also how much force we are applying. Isabella has developed a soft pneumatic optical tactile sensor that she's attached to a KUKA arm. In this project, you'll be performing a blind manipulation task (pushing shaped blocks into similarly-shaped holes). You'll probe the environment, develop a motion plan, and attempt to push each object into the corresponding hole.
  Skills needed: Strong ROS skills and a good safety record on robots (the KUKA is very expensive and more complex than Baxter).

- Modeling Soft Robot Contact Forces
  Sponsor: Valmik Prabhu, Sastry Group / HART Lab
  Valmik wants to do some contact modeling on the soft fingers in the lab. You'll start by doing some system identification (originally lab 4 from 106B) then test how well your models predict external forces.
  Skills needed: Some dynamics/controls background, and experience with optimization in Matlab.

- Human-Human Collision Avoidance
  Sponsor: Dexter Scobee, Sastry Group
  Dexter has been researching algorithms on learning motion constraints from expert demonstrations. Previous work has applied this to discovering physical constraints or task requirements and rules - arguing that assessing from data might be better than trying to specify manually. Your project could, for example, examine a case where manual specification is especially deficient: human social boundaries (also known as "proxemics"). By studying how far humans stay from passers-by, you can characterize the berths humans expect, and implement that on the Turtlebot.
  Skills needed: Some software engineering and data analysis.

- Hybrid System Modeling on Hardware
  Sponsor: David McPherson, Sastry Group
  Dynamic impacts are tough to model and plan through, but are essential for robots that push, lean, hop, or clatter against walls, floors, or backstops. Modeling these dynamics that suddenly change is the goal of this project. Current work on these Hybrid Systems (so called because they fuse multiple continuous dynamics together) found ways to relax the discontinuities so they can be treated with more conventional algorithms. The goal of this project is to apply the relaxation technique to a simple real-world system. If you're interested in getting into theoretical controls reseach, this could be a good way to dip your toe in the water.
  Skills needed: David will handle most of the math, but a strong math background would be beneficial.

General Ideas

- Make robot art! And enter it here (if they ever hold another competition)

- Have Baxter play a board game! Chess and Checkers are overdone, but something a bit more complicated would be very cool. (I'm partial to this)

- Collaboration between multiple robots. Have two Baxters collectively pick up an object or implement some searching algorithms on turtlebots.

- Track the surface of an object using position control using vision and/or force feedback.

- Make a turtlebot carry your stuff! Have it follow you around using image tracking.

- Measure an object's hardness, compliance, or coefficient of friction.

- Have Baxter copy a human's motions. IMU or Kinect based tracking is overdone and a bit too easy, so don't do that. There was a lot of work done cerca 2005-2010 on estimating human 3D kinematics from their 2D poses, so combining this with a modern 2D pose tracker like OpenPose could be a cool project. You could also try building your own skeleton tracker or using a novel sensor.

Available Hardware

We have some hardware that you may use, depending on your proposal.

- Baxter (3x)
- Sawyer (2x)
- Turtlebot (6x)
- Ridgeback (1x). The ridgeback has a LIDAR and cartesian control.
- Realsense 3D Cameras (many). We have several types, including ones with integrated IMUs and SLAM.
- Kinect 3D camera (2x). Some packages work better with kinect than realsense.
- Logitech C922 Cameras. (6x) High resolution wide-view webcams. 1080p at 30fps or 720 at 60fps.
- Microsoft Lifecams. (4x) Middle-of-the-road webcam. 720p at 30fps.
- Research Turtlebots. (3x) Valmik has some fancier turtlebots with onboard NVidia Jetson Nanos and Realsenses.
- Crazyflie Drones. (6x) The Sastry group has a set of Crazyflie drones that can be made available for projects we deem good enough. We also have some larger drones, though we'd need you to have pretty extensive experience before we'd consider letting you use them.
- Motion Capture Room. The Sastry group has a motion capture room you can use for HRI projects.
- Haptic Device (1x). The Sastry group has a 6-DOF haptic feedback joystick. You could possibly use this for impedance control or some other human feedback project.
- Dynamixel Servos (many). Dynamixel servos are like RC hobby servos, but give you much more sensor information. They're great for control projects.