

## Introduction

Welcome to 16B lab! We are so excited to have you.

**The main goal of lab is for you to gain experience applying concepts from lecture. You will build your physical intuition and confidence with problem-solving skills, including critical thinking, design thinking, and tenacity via debugging.**

This goal subsumes the following sub-goals:

1. Build the confidence to get started on something when you don't know how it will end.
2. Know how to check your work without merely checking each step along the way.
3. Know how to simplify a problem and identify its base cases.
4. Understand how to try different approaches without knowing whether they will work, and how to recognize when in fact it has or has not worked.
5. Understand how to try these approaches systematically instead of randomly, and be able to explicitly express what tentative assumptions you are making or which possibilities you discover while exploring.
6. Know how to work backwards — assuming that you could somehow by magic get to intermediate point X, how could that help you get to the goal? And, be able to take initiative and explore whether you can in fact get to intermediate point X.
7. Be able to take given components and use them to get the result that you want.

You will be completing either **hands-on** or **lab lite** labs. Hands-on labs involve physical circuit building and debugging. Lab lite labs build an understanding of circuit building concepts in a software format, through simulation and analysis. In any given week, both labs will emphasize the same lecture concepts and design goals.

We want lab to be a positive experience for everyone; in fact, the point of lab is to be rewarding and satisfying. However, this does not mean that lab is supposed to be easy. The staff are here to support you and provide you with the resources (including mental schema) you need as you build the perseverance to debug, but we will never do your work for you. That being said, if you are having a hard time or feel that you are falling behind in the class as a whole, please do not hesitate to reach out to your lab TA: first and foremost, we are here to help you.

## Grading and Policies

Lab is worth 50pts (out of 300pts total) of your final grade for 16B, for both hands-on lab and lab lite. We believe it is possible for every student to perform highly in lab if you work diligently, pay attention during checkoffs for hands-on labs and attend help sessions for lab lite, and follow the tips outlined in the final section.

Within lab, grading is broken into:

Labs (4 total)	40%
Project	60%

The project breakdown is as follows:

Checkpoints (5 total)	60%
Integration/Final Demo	20%
Final Report	20%

The following section on lab policies is broken down between hands-on lab and lab lite.

## Hands-On Lab

- **Attendance is mandatory, and you *MUST* come to your assigned lab section.** This is because this class is very full, and lab sections only have enough staff to support the students registered for that section.
- Hands-on labs are graded on an all-or-nothing basis.\* Being checked off on time means that you have received full credit for the lab. A lab is considered “on-time” if you are checked off any time before your next lab section, so you have one week to complete each lab. If your lab is late, 50% of the credit will be deducted. Extensions are given at the discretion of your lab GSI. Checkoffs can be viewed on Gradescope.
- \*TAs will accept high-effort, close-to-done labs at their discretion for full credit given thorough understanding of the lab. This is to reduce overflow and stress as much as possible.
- If you did not finish your lab in your section, find a section that works for **both** you and your partners. One of you should email the TA that leads that section >24 hours in advance to ask if they have space for you in their section. CC your normal section’s TA and group members. Format the subject line as “[EE16B] (time of lab to attend) Makeup Lab.” If you attend a section without prior explicit approval, you might not receive help.
- Labs are an essential part of the course. Therefore, if by the end of the semester **you miss 4 or more submissions, you will fail the class.** Your final grade will be an NP or F depending on your grading option.
- **All** partners must be present for checkoff. You will be working and getting checked off in your groups, but credit will be given on an individual basis. At least one group member must have a functional circuit to be able to receive credit, but all group members must have made significant progress.
- Circuits must be kept neat, according to circuit building guidelines.

Here is quick list of important things to consider for a successful hardware assembly:

1. Be neat and organized. All breadboard wiring should be planar - avoid spaghetti wiring.
2. Measure the voltage at circuit nodes as you are building your circuit up and compare with your expectations. This will help you identify problems early.
3. Often check for loose contacts. These are the main reason for circuits not working - or working unreliably.

## Hands-on Lab Structure

- Hands-on labs are 3 hours long, led by one TA and staffed by several lab assistants. Every lab will start with a short lecture (approx. 15 minutes in length) given by your lab TA over Zoom that will give you an overview of the lab, review the relevant theory, and give you useful tips that will help you avoid common mistakes. After the lecture, you will have the rest of the lab period to work.
- If you need assistance during the lab period, you can submit a help form and a TA/lab assistant will join your Zoom call when they are available. The process for checkoff is similar; you will fill out a checkoff request form and a TA/lab assistant will join your Zoom call. **You MUST have your checkoff request submitted 10 minutes before the end of lab** to give you a bit of a time buffer in case the queue is long so that staff can get to you before the next section starts.
- You will work in groups of 3 to 4 with other students in your section. Ideally, this group will be the same each week, but you can change groups until the project starts. Once the project starts, you must stay with your group through the rest of the semester.

## Lab Lite

- Lab lite can be completed **asynchronously**, and there are no set section times that you must attend. We recommend that you set aside time each week to complete the lab and ask any questions you may have. There will be scheduled lab lite-specific office hours each week for questions, and we encourage you to take advantage of this time! Lab lite questions will not be answered on Piazza by staff, although you are welcome to discuss with other students on Piazza.
- Labs are submitted online and are graded on correctness by an autograder that will be run after the lab deadline. You will have one week to complete each lab. Labs cannot be submitted late for credit.
- Labs are an essential part of the course. Therefore, if by the end of the semester **you miss 3 or more submissions, you will fail the class**. Your final grade will be an NP or F depending on your grading option.
- Every lab lite student must make an individual submission for each lab. However, you are welcome to work in pairs or in groups to share ideas, as long the work you submit is your own.

## LPTs: Lab Pro Tips

Following these tips will ensure you succeed in and get the most out of lab.

1. Read through the lab note and lab notebook before coming to lab. Think carefully about what possible bugs you may encounter, or which parts of the lab will take longest, and have a plan for avoiding those bugs and staying on-track time-wise.
2. If there is a lab problem on the homework, make sure you do it prior to your lab section. We put these problems on the homework to save you as much time as possible in lab and perhaps even help you finish early. This and tip number 1 are the top tips for making sure that you finish on time and get the most out of lab — if you follow these tips, you won't be scrambling to finish and will have the time to develop a deep understanding of the lab.
3. Talk to the other students in lab, not just your partner(s). Utilize Piazza and other electronic platforms to ask others if they have encountered similar bugs or problems and what they have tried to fix it. Or, if you've already fixed that bug, offer them some pointers.
4. For hands-on labs, as you're working through the lab, formulate sanity-check questions that allow you to quickly check if there is something wrong with your circuit. Ex: *What should VDD and VSS be? What voltage do I expect at this node? What do I expect the signal at this node to look like?*
5. For hands-on labs, get to know your lab partner(s). You will be working with them all semester, including the entirety of the project. This also extends to the other students in your section. For lab lite, form groups to work on labs together each week. It's much easier to work with friends!

## Syllabus

Lab lite and hands-on labs will both follow the same structure and teach similar concepts each week. Lab lite students will not complete hardware components of the lab described below.

Dates	Lab	Overview	Goals
1/18	Syllabus Week	No Lab	
1/25	Lab 1: Tinkercad Intro	Build a circuit virtually on Tinkercad.	Practice simulating and translating circuit schematic onto a breadboard.
2/1	Lab 2: Debugging	Build and debug an inverting amplifier.	Review digital logic, practice good circuit-building and debugging techniques, and re-familiarize yourself with lab equipment.
2/8	Lab 3: DAC/ADC	Build a 4-bit DAC using the MSP430 and a resistor net. Modify the DAC to build a 4-bit SAR ADC by adding a comparator and implementing binary search.	Review superposition and continue familiarizing yourself with the MSP430.
2/16	Buffer Week	Buffer Lab	Finish DAC/ADC.
2/22	Lab 4: Color Organ	Use the mic board and filters to illuminate different LEDs depending on sound frequency.	Explore low-pass, high-pass, and band-pass filters.
3/1	Project Part 1: Front End Circuits	Build car and test motor behavior.	Build the front-end circuitry for the car (neatly, to minimize chances of wires coming loose later)
3/8	Project Part 2: System ID	Profile motor behavior and determine operating point.	Explore modeling and linearization using least-squares as a precursor to controls.
3/15	Buffer Week	Buffer Lab	Finish System ID.
SPRING BREAK 3/22 - 3/26			
3/29	Project Part 3: Closed-Loop Control	Implement and fine-tune closed-loop model to make car go straight.	Explore discrete state-space control via eigenvalue placement.
4/5	Project Part 4A: SVD/PCA	Record voice samples, find PCA vectors, and implement cluster classification algorithm for samples projected onto PCA subspace.	Explore SVD and PCA as they relate to data science in order to distinguish different commands.
4/12	Project Part 4B: SVD/PCA	See above.	See above.
4/19	Project Part 5: Advanced Controls	Make car turn and implement classification on MSP430.	Use SVD/PCA in order to make your car correctly respond to live voice commands.
4/26	Project Part 6: Integration	Make the car respond to voice commands.	Bring everything together and achieve understanding of the complete system.
5/3	Buffer Week	RRR Week	Finish Integration.
SCHEDULE IS SUBJECT TO CHANGE.			