Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.115 AND 6.1151
Microcomputer Project Laboratory

January 6, 2024

General Information

Lectures:

- T/R, 1-2 PM, W 3-4pm, Room 35-225
- Prof. Steven Leeb, sbleeb@mit.edu, Office hours: Anytime

Laboratory Teaching Assistants:

- Aaron Langham, alangham@mit.edu
- Dylan Brooks, brooksd@mit.edu
- The TA lab office is Room 38-691,x3-1938

Course Web Site: web.mit.edu/6.115
and: web.mit.edu/cdev (for software)

Reading Material

Please **purchase** *Practical Electronics for Inventors,* by Scherz, available at Amazon. Please also purchase *Learn Digital Design with PSoC, a bit at time* by Van Ess. Note that these are available as electronic books and Amazon has a free reader. You can find an additional, free electronic book about one of our two microcontrollers, the Infineon Programmable System on Chip (PSoC), on the course website here:

http://web.mit.edu/6.115/www/document/psoc_book.pdf

Additionally, we will **share** electronic copies of *Programming and Interfacing the 8051 Microcontroller* by Yeralan and Emery, the *MCS-51 Microcontroller Family User's Manual* from Intel (on-line on the course website), and the *R31JP User's Guide* from Rigel Corporation when you check out your kit – **please be sure to return/delete the Yeralan and Rigel books** when you finish the course, they are a loan. The first two chapters of the Yeralan text are excellent reading for getting started with the 8051. As a general rule, look in the Intel Manual **first** when you have questions about the 8051 microcontroller.

If you wish to find additional problems or a different slant on the material, the following helpful texts are available in Barker and may be purchased or ordered at the Coop or on Amazon:

- *The Art of Electronics,* Horowitz and Hill, ISBN: 0-521-37095-7.
- *The 8051 Microcontroller*, I. Scott MacKenzie, ISBN: 0-13-780008-8.
- *Programming and Customizing the 8051 Microcontroller,* Myke Predko, ISBN: 0-07-134192-7.

Kovid

The uncertainties of modern times will not deter us from having fun with embedded control and design this term! To make sure that we are able, always, to build to win, we are planning ahead this term! Of course, we will use the 38-600 lab and we look forward to working with you in 3D at a bench.

Obviously, if you are feeling ill, let us know and we will work with you. We are teaching this class because we care about you, your growth as an engineer, and your future. Have faith please, and don't panic.

We have spent a fortune on extra test equipment so that we can loan you a lab kit and other gear in your living area, e.g., if you "feel fine" but are waiting for a Kovid test. **Always be ready to work at home if the need arises.** We expect that you will plan to always have access to your gear. Please **do not travel with your kit far off campus**, but do keep your kit with you, not stuck in your locker, for use in your living group if and as needed. Many of the lab exercises this term can be completed at home with the kit that we loan you. Although not required – we have computers in the 38-600 lab for your use – it may be convenient if you have a Windows 10/11 machine available to use "at home." We will provide you with free software that will let you reproduce the needed 38-600 lab computer capabilities on a Windows 10/11 machine.

Internet-iquette

Your agreement to the class sign-in documentation, including this introductory handout, is your word that you will help us maintain lab safety, academic integrity, and internet discipline for the course as we proceed. Specifically, please:

- Do NOT post course materials, labs, your solutions, lecture handouts, etc. to any online sites. Of course, you may turn in your work at our course website per our requests. But please do not load material onto sites like github, or share the course materials or your solutions on the internet.
- Do NOT share zoom links if we happen to use them.
- Do NOT forward course e-mails to others.
- Do NOT record lectures, checkoffs, or other course interactions.
- In dire emergencies, optional makeup lectures may be scheduled for Tuesday 4-5:30 slots.
- Do NOT use tools like "ChatGPT" to complete your labs. Doing so is cheating. And these "tools" frequently produce wrong answers.

SAFETY

The 6.115 laboratory will introduce you to very exciting material with enormous relevance to many important industrial and commercial products and processes. This class will teach you techniques for modeling and controlling dynamic systems of many types. It will also give you unique experience in designing circuits and building and debugging your designs. We think you are going to love these laboratories.

You will be required to read, understand, and follow a safety briefing handed out with this document. **Wear safety goggles** (available in 38-501) when powering up circuits, e.g., circuits with large electrolytic capacitors, even at low voltages. Wear safety goggles when cutting component leads – wire fragments can get in your eyes. Be careful when using tools. Use good sense and NEVER do anything about which you are uncertain. Do NOT, under any conditions, attempt to repair or modify or access the inside of your lab kit, i.e., the part that plugs into the wall to provide you with power supplies. Ask the staff if you have any questions about how to use a tool or safely test a circuit or if you have a problem with your kit.

If we feel that you are ignoring the safety rules or failing to take adequate precautions, you will be dropped from the class.

We expect, and will tolerate, no accidents in this class.

Ask if you need help or are uncertain, we are here to work with you.

Laboratory: Exercises and Final Project

If possible, we recommend that you set up a dedicated area for your lab kit "at home." This will allow you to bring the kit to 38-600 **and** also to work at home, as convenient for you. Please maintain situational awareness. Use **only** the 6.115 laboratory area in 38-600, not the areas assigned to other classes. Learn what your equipment can do, e.g., the capabilities of your kit, multimeter, oscilloscope, etc. Be aware that the course texts, Scherz and the microcontroller manuals, have copious information on many topics. Read what you need, not simply what we suggest. Use the index. Check the required and the recommended books and the datasheets if you need additional information about components.

There will be a Lab 0 that serves as a "prelab" and four assigned laboratories with the hardware kit. At the end of the term, you will build an individual final project of your own conception, with the approval of the 6.115 staff. Start thinking about what you might want to make early, especially if you'll need special equipment or components. Projects should be tractable in a 3-or-so week period, fun, and illustrative of your mastery of the course material. Past projects have included device programmers, voice/sound players, internet appliances, video games, custom calculators, and robotic systems. **The scope of this work must use the PSoC microcontroller system** that we'll use throughout the term, and must be independently demonstrated without reliance on components, inputs, code, or other hardware from other students.

With permission of the instructor, you may enroll in 6.1151. Registering for 6.1151 involves an expanded final project conducted throughout the term, and which contributes towards the "independent inquiry" (II) requirement for your EECS degree. Students in 6.1151 receive 15 units instead of 12 units for 6.115. If you choose to do 6.1151, you are agreeing to put in 3 additional hours each week of the entire term on your expanded final project. If you wish to do this, you must **discuss your II proposal project with Professor Leeb and complete and submit your II proposal before the February 15 lecture, and get started early.** Of course, you may not know important facts about microcontrollers that you will need for your project until later in the term. However, early in the term, you can get started with other pieces of your expanded 6.1151 final project. A separate document describes the independent inquiry proposal and requirements for 6.1151.

We have invested in (see the "Equipment in 6.115" page, attached) new, state-of-the-art microcontroller development stations, the R31JP and PSoC 5LP boards, for you this term. They are portable, and plug conveniently into the 6.115 lab kit that you will be issued. You program the R31JP using a serial port on a personal computer running Windows 10/11. A USB-to-serial converter should also work well.

Please invest now in several USB keys or similar storage that you can use to store and back-up your programs. Back-up your programs throughout the term! Make several copies. Do NOT leave your code only on your computer, back it up. Transfer copies of your code to your athena account, for example, for redundancy.

We will have a lecture on February 14 familiarizing you with the use of your hardware lab kit. Do NOT use the hardware until we have discussed it together in class. Do NOT disassemble or dismantle any of the microcontroller boards. For example, do not remove IC's from the R31JP or other microcontroller boards we give you.

Quiz and Lab Check-Offs:

There will be one quiz, given in lecture on Thursday, April 18. You will submit your Lab 0 writeup as a PDF file, no larger than 2 megabytes, to the course website at the turn-in time. If needed, use a free site like this one to shrink your pdf:

https://smallpdf.com/compress-pdf

For the remaining labs, **neat and clear** laboratory write-ups in a laboratory notebook that we will give to you are to be presented at your laboratory check-off interview. Commented printouts of your laboratory code for **all** exercises and electronic submission for select exercises are to be turned in on the due date, without exception. Laboratory check-off interviews with the TA's will be scheduled as indicated on the course calendar. Sign up for a check-off time on the posted schedule on the course web site for each lab. Please do **not** be late to class (in general, but especially so on quiz day) or laboratory check-offs. We are attempting to accomodate a large number of students without limiting enrollment. This means that missed appointments will not be easy to reschedule. **Generally, we will not make alternate or make-up arrangements for the quiz and other assignments**. In the event of a sickness or dire emergency, please call us **before** the quiz or check-off to let us know, if possible.

Grading Policy

FOR 6.115:

Your final grade is based on a sum of points for each class activity, including labs, a quiz, and your final project. You can earn a maximum total of 100 points during the term, distributed across the class activities as shown:

- Attendance (taken randomly) in Lectures and Chalk Talks (mandatory!) – 5 points
- 5 Laboratories – 10 points each, 50 points total
- Quiz – 25 points
- Final Project – 20 points

You must score at least 50 total points and attempt **all** exercises in order to receive a passing grade. Accumulated point totals of 85-100 receive an A, 70-84 receive a B, 60-69 receive a C, and 50-59 receive a D. Assignments must be turned in on time to receive credit. You must return the kit gear to us at the end of the term to pass the class and avoid a bursar's charge.

FOR 6.1151:

Your final grade is based on a sum of points for each class activity, including labs, a quiz, and your final project with independent inquiry component. You can earn a maximum total of 120 points during the term, distributed across the class activities as shown:

- Attendance (taken randomly) in Lectures and Chalk Talks (mandatory!) – 5 points
- 5 Laboratories – 10 points each, 50 points total
- Quiz – 25 points
- Final Project with Independent Inquiry – 40 points

Your total points are divided by 1.2 to compute your "scaled score". You must achieve a "scaled score" of at least 50 total points and attempt **all** exercises in order to receive a passing grade. Accumulated "scaled score" point totals of 85-100 receive an A, 70-84 receive a B, 60-69 receive a C, and 50-59 receive a D. You must return the kit gear to us at the end of the term to pass the class and avoid a bursar's charge.

A separate document describes the Independent Inquiry component.

FOR both 6.115 and 6.1151:

For each of the five laboratory exercises, you will be asked to complete a **brief, neat** laboratory report, electronic PDF for Lab 0 and then in your laboratory notebook for Labs 1 - 4. You will also be asked to turn in neatly commented code. Your lab notebook should include sketches and tables of

laboratory observations, circuit diagrams, and brief text statements of explanation and analysis of your results in complete English sentences. Answer all questions posed in the laboratory handout in your notebook. A simple "demonstration" laboratory (you're not expected to **do** this lab, just read it!) and "approved" laboratory write-up will be handed out with this document to give you an idea of what your write-up should include.

After completing each laboratory, you will be expected to demonstrate your mastery of the material in an interview that will be scheduled with a teaching assistant. For each of the five laboratories, your writeup, code, and demonstration of your work will be worth a total of ten points. Your final project will also be documented with a report in your lab notebook and a personal interview. We will not publish solutions to the lab exercises. We want to discuss your questions and difficulties with you in person, preferably before the final check-off.

A tentative schedule of all assignments and lectures will be handed out. Every effort has been made to make the course calendar and assignment list accurate. However, the official MIT calendar is the ultimate source of information about key dates like add/drop, holidays, etc. Regarding class assignments, please listen for announcements of any changes as we go through the term. All aspects of this class are important for mastering the material and for your professional growth. Incompletes, i.e., grades of I, will not be given. The final letter grade will be based on the actual work completed during the term in accordance with the distribution shown under the grading policy.

Multimeter and PSoC Big Board

We will give you a multimeter and a PSoC "Big Board" development system to use in this class. If you complete and pass the class, you may keep this meter and the "Big Board" PSoC kit. If you do not wish to complete the class, please return the meter and PSoC "Big Board" along with **ALL** of your kit and other gear in "as-issued" condition to the staff in 38-600, in person, during posted lab hours.

Philosophy and Academic Honesty in 6.115:

In our humble and unbiased opinion, 6.115 is one of the most exciting classes you can take at MIT to further your professional growth as an engineer. Systems that employ embedded micro-control are all around you: music and media players, kitchen appliances like microwave ovens, cellular phones, calculators, television sets, and high performance aircraft, to name a few. In ways you may not realize, even very familiar consumer products that existed in some form before the microprocessor benefit in their contemporary incarnations from microcontrollers. A modern, high-end luxury automobile will typically contain more than a dozen microcontrollers to provide everything from engine and emissions control to music programming. This class is your passport into the world of people who love to build elegant, efficient systems that work.

This class is not particularly about learning how a specific microcontroller is programmed, or about designing circuits, or about wiring chips together. We'll do a little of all of these things this term, but our real goal is to introduce you to a palette of tools and techniques that let you build what you can imagine. These techniques are much more general than the details of a single processor or programming language. Chips come and go, but successful approaches for engineering design have a life that spans many iterations of a particular technology.

The creation of a successful micro-controlled system almost always requires more than the application of a set of analytical or programming techniques. The most elegant examples are crafted by engineers who have a rich understanding of how to make trade-offs amongst all the parts of a system, e.g,, software. thermal, mechanical, electrical, and chemical. For this reason, we make special efforts to expose you to a huge number of demonstrations developed from a wide range of engineering disciplines, and to provide exciting laboratory experiences that let you try the techniques you learn on practical hardware.

You are encouraged to collaborate with others on the conceptual solution of laboratory exercises. That is, you're welcome to discuss ideas and approaches for solving problems with anyone in the class. We believe that there is much to be gained when learning is a shared experience, provided that everyone in the group participates. Whether you collaborate or not, the final code, demonstrations, and lab reports you hand in should be entirely your own work and you should acknowledge (by including their names) others with whom you have discussed the problems. If you use other sources, they should also be acknowledged.

The use of "bibles" for these exercises is strictly prohibited. Your final code must be your own work. We have altered the labs this year in both obvious and subtle ways to distinguish correct solutions from work copied from bibles, and we will check and compare your lab solutions with others in the class. The use of "bots" like ChatGPT to write your code is also strictly prohibited. Please do not test us or risk your future by cheating.

It is immature and dishonest to copy the work of others (like an old solution or a friend's solution) and submit it as if it were your own. Since problems serve to guide you to develop the skills needed in this subject and your future career, not to do the work yourself is foolish; you will fail the quiz and the final project. Of course, the quiz is to be worked strictly on your own.

Plagiarism or other forms of cheating are intellectually and personally dishonest. Such dishonesty is a severe breach of the Institute's communal standards, as well as those of the engineering profession. Infractions will be dealt with severely.

Equipment in 6.115:

Each student will be issued a beautiful "Blackbird" 6.115 laboratory kit. These kits have been painstakingly constructed by the 6.115 teaching staff at enormous cost in time and dollars. Please treat the kits like fine china, so that others will be able to use them in the future.

In the past, students in 6.115 have had to wire up a collection of five or six chips to form a "minimum" computer system before any programming or system construction (fun) could begin. We are very fortunate this term to have received generous gifts from four philanthropists, Dr. T.J. Rodgers (Cypress Semiconductor), Mr. Ron Koo, Mr. David Grainger (The Grainger Foundation) and Dr. Manny Landsman (Landsman Foundation and the American Power Conversion Corporation), and also from the Guidant Foundation. These gifts have been used to purchase and customize the lab kits and the R31JP microcontroller boards that you will use this term. Additionally, the 6.115 staff and a team of technicians, UROP, and graduate students have invested over five man-years of labor and design work developing the equipment that you will be using this term. A small fortune in very expensive peripheral chips and test equipment has been donated by Cypress Semiconductor, Analog Devices, the Intel Corporation, Hewlett Packard/Agilent, and Tektronix. All of this largesse has been brought to bear in 6.115 this term to eliminate tedious tasks and maximize your opportunity to design and be creative with state-of-the-art tools.

Please take care of the equipment you use this term as if it were your own. The kits, R31JPs, and PSoCs are delicate, expensive, and they have been constructed for you this term. We will not accept careless use of this gear that results in damage.

Think before you simply replace damaged parts. How were they damaged? What steps are you taking to make sure that this damage will not occur again? CMOS components are particularly sensitive to damage from static discharge, for instance, and should not be handled by the pins. Mechanical connectors on the R31JP boards and the lab kits are not designed for abusive levels of force. Cables to the kit and R31JP board are not intended for use as handles. Please think and be careful. If you think your R31JP board is damaged, see Professor Leeb. **Questions about broken hardware or problems with the kit should be made directly to Professor Leeb, not the course staff.**

If you do not return your kit on the last day of the class, you will be charged for the kit and you will fail the course.

Please sign below to indicate that you have read this ENTIRE document, have Professor Leeb sign as well, and then take this sheet to the instrument room on the fifth floor of Building 38 to receive your 6.115 lab kit.

Your signature: Neatly print your name:

_____ _____

Professor Leeb's signature: Please issue this student a 6.115 lab kit, February 2024.

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