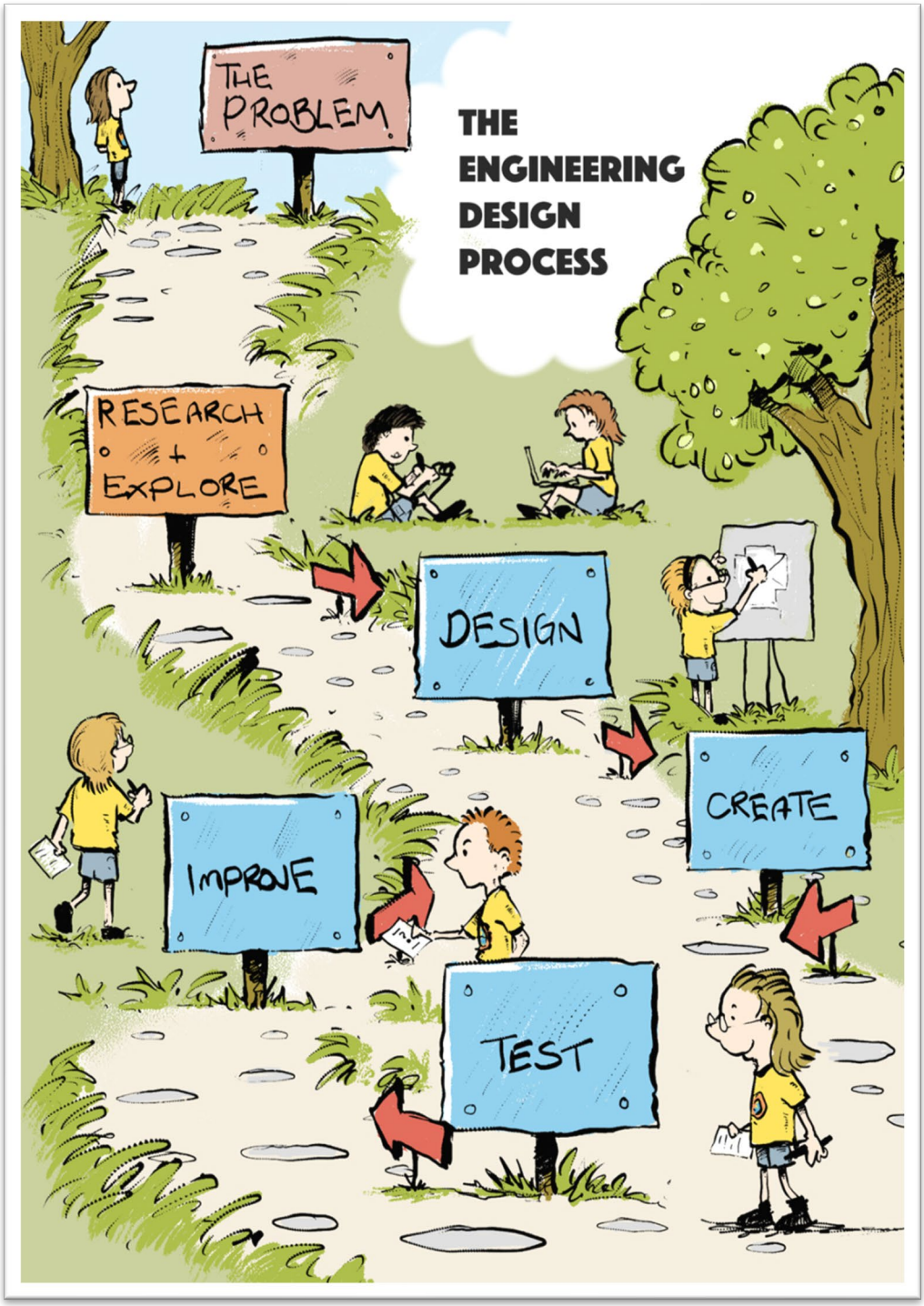
FINAL PROJECT MANUAL

ESE5190: Smart Devices


THE PROBLEM
THE ENGINEERING DESIGN PROCESS
RESEARCH + EXPLORE
DESIGN
CREATE
IMPROVE
TEST

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1 Overview

We have finally arrived at the final project. This is the opportunity for you to apply your knowledge and showcase it. The final project is an open ended project. As such, you should feel free to do whatever inspires you. However, since this project is worth 40% of your course grade, there are some requirements for guidance.

Read through this entire manual before beginning so you know what is expected.

Most importantly, have some fun! This is your project. You can take it as far as you'd like.

2 Learning Objectives

Applications of concepts learned throughout the course which includes but are not limited to:

- Power Management
- Noise filtering
- Timers, PWM
- ADC
- Communication
- Architecture, memory, assembly
- Interrupts
- Special Topics

3 Timeline

Deliverable	Due Date
Team formation	Wednesday, November 1, 2023
Project ideation	Friday, November 10, 2023
Group A Project Proposal Presentation	Monday, November 13, 2023
Group B Project Proposal Presentation	Wednesday, November 15, 2023
Project Proposal Feedback	Friday, November 17, 2023
Group A, B Project Proposal Write Up	Sunday, November 19, 2023
Milestone Demonstration	Monday, November 20, 2023 8:30 AM to 11:30 AM K-Lab
Group A & B Final Demonstration	Friday, December 8, 2023
Final Project Feedback	Monday, December 11, 2023
Final Report	Friday, December 15, 2023

4 Project Teams

Each project team will comprise of 3 students, unless there is a special reason to have a smaller team. All team members in the group will receive the same grade unless there is a significant discrepancy in effort and work. Any conflicts must be brought to the attention of the teaching team to resolve as soon as possible.

5 Requirements

5.1 Topics

- Choose at least three of the following topics to cover/include in your solutions:
- Timers (PWM, Input capture, output compare, etc.)
- Interrupts
- ADC
- Serial/wireless communication
- Power management
- Any advanced topics (E.g. digital signal processing, wireless communication, machine learning, path planning, 3d graphics rendering, analog processing on sensor data, cloud computing, IoT, wireless communication etc.)
- Other (requires approval from the teaching team)

5.2 Input Device

Use at least one input device (usually a sensor).

5.3 Output Device

Use at least one output device (e.g. usually an actuator but can be a display).

5.4 Complexity

It should be at least the complexity of Lab 4: Pong, if not higher. Creating a device that blinks an LED and prints “Hello World!” when a button is pressed is not an appropriate level of complexity. Discuss with the teaching team if you need help or if you want to check an idea.

6 Restrictions

6.1 Bare metal requirement

You are encouraged to use the ATmega328P for your final project, however if you prefer to use a different microcontroller, you will need to get approval from the instructor. Your microcontroller must run bare metal C; using Arduino .ino style firmware will result in a 0.

There is one exception to this rule - the ESP32 Feather Wi-Fi module. This may be used as a module to bring Wi-Fi to your project, but should not be running any application code. An example use case: You want to connect an RC car to your smartphone to drive around. Though the car is driven by application code on the ATmega328P, it communicates with the Feather module to send and receive data from the smartphone.

6.2 External Libraries

All code must be original with the exception of the standard C library, the AVR libraries, libraries provided for the labs, and the FreeRTOS libraries. If you choose to include external libraries instead of writing your own (e.g. WiFi, SD card reader, LCD, etc.), you must demonstrate in the final report that you understand how the library works in depth (e.g. what is the communication protocol, how is data being transferred, structure of the library, etc.) in an appendix. Additional points will not be given for the use of libraries but points will be deducted if a library is used and is not explained in the final report.

If you have any questions, please contact the teaching staff.

6.3 Batteries

If using batteries, you are only allowed to use NiMH or NiCd chemistries for your final project. This is due to current safety restrictions from UPenn EHRS

7 Previous Projects

Look at some of the past projects if you want to get some ideas of what's possible:

- Spring 2022
- Spring 2021
- Spring 2020

8 Academic Integrity

We will be reviewing your team's github repositories. There is a zero-tolerance policy for cheating. If plagiarized code is found, a failing grade for the final project will be given. Note that external libraries are not permitted unless you include an appendix (explained in the section above). When in doubt, check with the teaching team and cite your sources.

9 Project Proposal

Make a copy of the Final project proposal submission template and fill out the required information. Save a copy of your document as a pdf and submit it on Gradescope. You may add any additional sections that you feel are relevant.

Upload up to 5 slides + 3 min presentation video (video is optional). To upload a video, upload it on YouTube and then on the google slides, go to Insert > Video and paste the YouTube video link.

These proposals will be evaluated by your peers so you can choose to record a video presenting the slides or omit the video. If you choose to omit the video, make sure that the information on the slides are sufficient enough for someone to understand the project.

As part of the participation grade, each student will leave comments/questions for each group during the presentation. Your team will receive the class feedback as well as feedback from the teaching team afterwards.

10 Requirements Specification

Requirements specifications are documents that describe business requirements, system requirements, features, functions, and constraints of a product, just to name a few. They are used to communicate the expectations and needs of the stakeholders, such as the customers, users, developers, and testers. Developing Requirements Specification is an important part of a new product development cycle. Developing good requirements specification is a skill that is valued by product development companies. You will develop a Software Requirements Specification (SRS) and a Hardware Requirements Specification as outlined in the Appendix, and include them in your final report.

11 Parts Order

Parts orders will be placed on each Monday and Wednesday (submit them before noon!):

If you do not need additional parts outside of your parts kit, no need to place an order. There are many parts already available in the lab so check with the staff prior to placing an order. The Detkin staff will review your order and if a part is already available in the lab, then you will be able to pick it up from the lab and the amount will not be deducted from your budget. You can place parts order more than once.

There is a budget of $125/team.

For each parts order, fill out this form. You'll be asked details about the vendor and parts.

12 3-D Printing and Laser Cutting

Laser cutting and 3D printing is available in RPL and Tangen Hall. Training is required for both RPL and Tangen Hall. Information on RPL training can be found here and information on how to get started at Tangen Hall can be found on the Tangen Hall Course Canvas page.

13 Milestone Presentation

Your team will have a total of 5 minutes to present project milestones. During the presentation your team will show Minimum Viable Product (MVP). We are trying to reserve lab time for these presentations, however since lab time may be limited, there may not be enough time for all groups to present, in which case groups will be selected at random to present. Teaching staff will go to each table's station to evaluate the milestones.

14 Final Demonstration

The final demonstration will be done on Friday Dec 8 between 10:15 am and 4:45 pm.

Your team will set up your project at a station in the lab to showcase your project. The teaching team will be evaluating each team's project.

This event will be open to the Penn community and general public so if you have friends you would like to invite, let them know!

You will need to record a demo video for the final demonstration. The video will be due on the same day as the final report. The video can contain a presentation and/or just demonstration of your final project. The video will need to be uploaded on your devpost. You can also have the presentation or slides playing on the monitor during the showcase as well.

15 Final Report

Make a copy of the final project report template and fill out the required information. It will be very similar to your project proposal except this time, you will reflect on and evaluate your project. You may add any additional sections that you feel are relevant. Submit your final report on gradescope.

16 Extra Credit

Up to 10 points of extra credit will be rewarded to teams that go above and beyond with their projects. This will be determined via feedback from the other teams as well as evaluation and observation by the teaching team.

17 Devpost

We will be using devpost to compile all of the projects in one location. Click here to create a listing for your team. Your devpost does not have to be very elaborate or complicated. You should update it throughout the final project duration. It can prove to be a useful website to showcase your project to employers.

At the bare minimum, the page must have:

1. Image the final product
2. Video of the final product
3. Project overview

18 Submission Requirements

1. Click on this link to create your repository on Github Classroom, if you haven't already. Name your repo to be final-project-groupx where the "x" is your group number.
2. Create a devpost about your project.
3. Use the final report template to write your proposal (Canvas). Name your lab write-up PDF as final_report_team-x where the "x" is your team number. Submit your pdf on gradescope by the due date.
4. Attend the final showcase.
5. The following files are required to be in your repository by the due date of the final report:
   a. Any code written for your project.
   b. README on how to compile and run your code
   c. Include devpost link in your README
   d. Include links to any YouTube videos that you uploaded in the README

19 Grading Rubric

The following files will be graded in addition the presentation and team's devpost:

- proposal_groupx.pdf
- final_report_groupx.pdf

Item	*Points*
Project Proposal	100
Milestone Demonstration	50
Final Report + Demo	150
Project Requirements	
Devpost	15
Topics	5
Input Device	5
Output Device	5
Complexity	70
Software Requirements Specification	25
Hardware Requirements Specification	25
Extra Credit	10

Appendix

1 Requirements Specifications:

Software and hardware requirements specification help to ensure that the product meets the needs of users and stakeholders. In regulated industries like medical devices and aviation, they are mandated by governing bodies like FDA and FAA for systems comprising hardware and software. They are also used widely in non-regulated industries.

Major benefits of requirement specifications are:

- Clearly defines what the software or hardware is expected to do
- Seeks to minimize or eliminate ambiguity between requirements and implementation
- Forces designers to think though the requirements before any design is undertaken, thereby minimizing the need for redesign
- Provides a realistic basis for estimating project timelines, risks, and costs
- Makes it possible to verify the software or hardware against predefined requirements

Hardware and software specification can run into hundreds or even thousands of pages. We will not be going to that extent for our final project, instead we will use this opportunity to learn to formulate key hardware and software requirements. Hardware and software requirements specification should ideally be about 1 page each, and should not exceed 2 pages each in your final report.

2 Requirement guidelines:

2.1 Requirements shall be:

- Explicit – Shall be clear and easy to understand
- Complete – Shall have sufficient details
- Feasible – It shall technically feasible to implement each requirement
- Consistent – Shall not contradict other requirements
- Accurate – Shall accurately define the functionality
- Testable – it shall be possible to test each requirement

2.2 Keywords to use:

Shall: Use ‘shall’ for mandatory requirements. E.g. the musical instrument shall generate 5 basic tones: 220 HZ, 247 Hz, 262 HZ, & 294 HZ

Shall not: Use ‘shall not’, to indicate absolute restriction or prohibition. E.g. the device shall not be powered by Li-ion batteries for safety reasons

Should: Use ‘should’ for recommended, but not mandatory requirements. E.g. The completed project should be able to generate 10 musical tones in addition to the 5 basic tones

3 Software Requirements Specification:

3.1 Overview:

Here you will describe the project in a few lines from a software standpoint

3.2 Users:

Describe who the users are

3.3 Definitions, Abbreviations

Here you will define any special terms acronyms or abbreviation you plan to use for software

3.4 Functionality

SRS 01 – *'Example: The IMU 3-axis acceleration will be measured with 16-bit depth every 100 milliseconds +/-10 milliseconds'*

SRS 02 – *'Describe software function 2'….etc.*

4 Hardware Requirements Specification:

4.1 Overview:

Here you will describe the project in a few lines from a hardware standpoint

4.2 Definitions, Abbreviations

Here you will define any special terms acronyms or abbreviation you plan to use for hardware

4.3 Functionality

HRS 01 – *'Example - Project shall be based on ATmega328P microcontroller'*

HRS 02 – *'Example 'xyz' type sensor shall be used for obstacle detection. The sensor shall detect obstacles at a maximum distance of 'xx' cm'*

HRS 03 – *'Example An 'x by y' cm LCD display shall be used for user interface. The display shall communicate with the microcontroller via I2C bus' 'Here you can also define any limitations'*