[This document describes the final written report required for your Senior Design(ECE/COE 1896) project. Use this template as a format for your report. Delete/Remove sections that do not apply to your project. Do not change the formatting in the template.]

[Editorial comments appear in this style (italic blue font in brackets, hidden font) and will not normally print with your document. You may delete the editorial comments after you understand them.]

ECE/COE 1896

Senior Design

<*Project Name*> Conceptual Design

Team#

Prepared By: (Team Member Name)

(Team Member Name)

(Team Member Name)

(Team Member Name)

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[Table 1: Example Table for ECE/COE 1896 Final Report. **Error! Bookmark not defined.**](#_Toc361750719)

[If necessary, insert a blank page after your Table of Tables to make the front matter end with an even page. You should be able to print your final report double-sided and have the page numbers appear as they would in a book.]

[The following sections must be included in your final report. You may add sections or subsections to suit the needs of your project, but do not omit any of the sections provided here, unless instructed to do so. Follow the instructions and examples in each section to build your report. If you insert material from other sources, make sure the format is consistent with this document’s original format. If you have trouble with the formatting, please consult your course instructor.]

# Introduction

This section should contain a brief overview of your project. In this section, you should describe the problem that your design will solve or unmet need that it satisfies. You should also include a high-level description of the prototype you will deliver. (~ 1 page)

# Background

This section should provide background information that will be important for understanding the problem and your proposed solution. For the problem, what areas of knowledge (science, health, economics, engineering, etc.) are important for understanding the problem, and the need for your design? Why is a better solution needed? You should provide background information on these topics, with appropriate references. For example, if your project were intended to make bicycling safer for commuters, you would include a few sentences about how many people commute by bicycle, how many bicyclists are injured each year, and what factors contribute to the safety problem.

You should also include background information that is relevant for your solution to the problem, also with appropriate references. For example, if a critical part of your design involves using ultrasound to measure the distance to something, then you should include some basic information about ultrasound and how it is used to measure distance. You should also include information about the state of the art for this problem. What other solutions currently exist, and what have others tried (possibly including notable failures)? What is unique about your design? (~2 pages)

# System Requirements

Describe the requirements for your system. Explain how your customer will use your system and the detailed requirements. Be clear in distinguishing between features the customer *requires* and features the customer *desires*. Note that the operative term is “**detailed requirements**”. The report should state what the requirements are, and in separate paragraph following the requirement statement, describe the details of or justifications for the requirement.

Here are some examples of design requirements for different projects:

* A voltage protection circuit, in which the load must be disconnected when the measured voltage is too high or too low. The voltage thresholds are design requirements.
* A communication system, for which the bit rate and range over which communication is possible may be design requirements.
* A wearable device, for which maximum weight and minimum battery life are design requirements.
* A project that includes a user application that must communicate with a database that runs on a server. The kinds of data to be stored on the server and the protocol that used to transfer information from the database to the user app may be design requirements.

In this section and the other sections that follow, you may use subsections, sub-subsections, and sub-sub-subsections to organize your work. When you use subsections, make sure you use the proper formatting styles defined with this document. Do not type the section heading and then manually adjust the format to match. You should use the Styles and Formatting window (available under the Format menu) to select and apply the appropriate style to each heading type.

## Example Subsection Heading

The above is an example of a subsection heading. Note the numbering and font size.

## Another Example Subsection Heading

Above is another example subsection heading. The following two sub-subsections and their corresponding sub-sub-subsections are further examples. Note the formatting, and that there are no blank lines inserted for spacing purposes. The formatting will automatically space paragraphs and headings correctly if you apply the appropriate formats.

### Example Sub-subsection Heading

Text for the sub-subsection.

### Another Example Sub-subsection Heading

Text for the sub-subsection.

#### Example Sub-sub-subsection Heading.

Text for the sub-sub-subsection.

#### Another Example Sub-sub-subsection Heading.

Text for the sub-sub-subsection. If you require more than four levels of headings, please consider revising your report to streamline the presentation.

# Design Constraints: Standards and Impacts

A constraint is a limitation imposed on some aspect of the system, by something other than the desires of the consumer. A design constraint limits on the options that are available to the designer, by setting immovable boundaries on some measurable quantities. The source of a design constraint may be industry or government standards, available materials or components, the impacts of a particular design choice, or anything else that is unrelated to the requirements of the consumer.

For this section you must describe constraints that limit your design in two categories, as described below.

## Design Constraints

**In addition to time, budget, and manpower, you must describe at least three**. Constraints that impose a limitation to the design from an external source. Constraints are different from design requirements; those are not based on customer’s needs.

## Impacts in Non-Technical Contexts

You must consider the impact of your solution in all of the following non-technical contexts and specify the relevance to your design problem, and describe what you expect the impact would be:

* Environmental
* Public Health
* Global, Cultural and Societal
* Diversity, Equity and Inclusion
* Welfare and Safety
* Economic (This must be unrelated to the project budget or the projected cost of the prototype. You must consider the impact of your design solution on the community, corporate, and national economies.)

If one possible solution to your design problem has a significant positive impact in any of these contexts, then that is a reason to favor it over others that do have positive impacts. On the other hand, a significant negative impact could be a reason not to consider that particular solution at all.

It is important to distinguish between design constraints and requirements, and students often struggle to understand the difference. One way to tell the difference is that requirements come from the desires of the customer for what the solution must do, while constraints come from other sources and often indicate what the solution must not do. Some examples are:

* A certain device must be able to deliver direct current to a load, up to a maximum of 1 Ampere. This current it a design requirement, but to meet it the solution must use at least 22-gauge wire, or 16-gauge wire if the length is greater than 2 feet. The wire gauge is a constraint imposed by government regulation, and is based on consideration of the impact of the design in the context of welfare and safety.
* A system that monitors and communicates health information about the user to a caretaker must measure various biological signals and determine parameters of the user’s state of health. The kinds of information communicated to the caretaker are design requirements, and the Health Insurance Portability and Accountability Act imposes a constraint that any such transfer of health information must be encrypted to ensure privacy. The development of HIPAA was, in part, based on the consideration of the impacts of solutions in public health, societal, and economic contexts, among others.
* Almost any project intended to be an electronic device for the general consumer, if it were sold in the European Union, would be subject to the Restriction of Hazardous Substances (RoHS) directive. The constrains products in terms of the levels of lead, cadmium and other harmful substances that can be present, and it is possible to purchase components that are RoHS compliant from many vendors. Although your project will not be sold in the EU, you might want to consider whether RoHS standard or other environmental constraints would be applicable and how they would limit your choices.

# Conceptual Design

This is the most important section of the document, and in it you will provide detailed descriptions of at least two different design concepts for a solution to your problem. The concepts can be very similar, differing only in a primary component or algorithm, as long as they represent different approaches to the problem. Then you will select one design concept as the best to implement and provide justification for your decision.

Begin by describing what the system must functionally do for the customer. The functions the system must provide for the customer will influence/determine the form of the solution. By “form”, we mean physical structure. Here, apart from the requirements, you describe the functions your system must perform (i.e. what your system must do) to satisfy the requirements.

Finally, choose one design concept, and proceed to justify your choice. We will evaluate this section based on the proper level of detail for both designs, and the justification you provide for your top choice.

## Design Concepts

Following the functional description, briefly introduce at least two conceptual design ideas that accomplish the objectives. Save the detailed descriptions of each concept for the sub-subsections that follow.

### Design Concept 1

Place each design concept in a separate subsection. Write clearly and concisely about what hardware you will build, and what software you will write, if this design concept is selected. You must be able to list viable options for most components and sub-systems, and provide enough detail so that it is clear how you plan to proceed in implementing your solution.

For each design concept, two questions must be answered clearly. What hardware will you design? What software will you design? Hardware design is not simply selecting and assembling components, it also involves determining the values for different components so that the circuit you build from them will satisfy the project requirements. Software design is not simply writing code that provides a user interface, displays data, or tests for a measurement crossing a threshold. Software design must include the implementation of a non-trivial algorithm that is central to the prototype satisfying the project requirements.

Include figures and diagrams to illustrate each design concept. Figure 1 is an example. The figure is centered on the page and has a caption directly following it. Insert captions using the References tab. In the Captions group, select Insert Caption and then click OK. After the dialog box closes, type the figure title after the figure number you just inserted.



Figure 1: Concept Car.

In your written text, you should refer to every figure in your report. To insert a reference to a figure, use the Insert menu, select the Reference option, and then the Cross-reference option. Choose the type of item you want to refer to and the style (typically “Only label and number” for the “Insert reference to” option). Select the appropriate caption and click insert. This approach will automatically correct your cross-references if you later insert additional figures.

### Design Concept 2

Each design concept will present an alternative solution for the project, and you must make it clear how the concepts are different, and what they have in common. In a later subsection you will select one of your design concepts as the best choice, and you must refer to the information presented in these sub-subsections to justify your selection.

### Design Concept 3

If you have a third design concept, which is clearly different from the first two, you should list that as well. It is uncommon for a team to have more than 3 design concepts that all address the problem, and which differ in some significant way.

## Selected Design Concept

In this subsection, you will indicate which of your design concepts you have chosen as the best solution. You must justify this choice, based on the ability of this design concept to meet the project requirements in Section 3, given the constraints in Section 4. You must make specific references to the requirements and constraints, and it must be clear to the reader that your selection is based on an objective analysis of the best solution.

Once you begin working on your project, you may find that you were wrong in selecting this particular design concept. Perhaps you will find that there are additional constraints that you did not anticipate, such as the availability or cost of critical components. You may also get feedback from the instructors or your domain advisor that a different concept is a better choice. It is expected that this will happen to one or more teams every semester, and it is not really a problem. If this happens to your team, then in your final report you will have an opportunity to explain why the change was necessary.

# System Test and Verification

Include a preliminary test plan. Specify at least 3 key performance criteria that are measurable, and will allow you to evaluate how well your prototype solves the design problem. Saying that the prototype simply ‘works’ or ‘doesn’t work’ won’t be good enough. Your test plan is how you verify all of the requirements. List the expected/desirable test outcomes and materials/equipment that you need to carry out the tests.

## Software Systems

Analytical, Type-1, and Type-3 tests

## Hardware Systems

Analytical, Type-1, Type-2, and Type-3 tests

# Team

Describe the composition of your team, the skills that each team member brings to the project and the division of labor. Everyone must assume sole responsibility for at least one aspect of the design. Your grade will primarily be a group grade and you are expected to work together and assist one another. However, you will be evaluated for your ability to accomplish individual goals at each Checkoff, and at the end of the semester you will receive an individual grade based on your individual performance. Roles will change as the semester moves forward, but roles cannot be ambiguous or vaguely described.

## Team Member 1

Use a separate subsection for each team member, where the title for that subsection is the name of the team member. Describe the portion of the project for which each team member will be responsible, and the skills that the team member has that make them well-suited for the task. Following that, you must address two questions. The answers to these questions should appear in sub-subsections as shown below.

### Skills learned in ECE coursework

An important requirement for all senior design projects is that the team members must apply knowledge they gained in their ECE program to the design. In this sub-subsection, you will indicate which skills team member #1 will apply that came from earlier courses. You must be clear about the skills that are required from this team member, and list the specific course(s) where these skills were acquired. You can include courses from departments other than ECE, if the team member completed these courses and the skills they learned there are relevant.

### Skills learned outside ECE coursework

While some skills you apply must come from your prior courses, every project will involve acquiring knowledge that is not covered in any course. This can include knowledge and skills needed to complete the design of hardware and software, prototyping skills, and domain-specific knowledge necessary to understand the problem.

Each team member must try to anticipate what they will need to learn in the coming weeks in order to contribute to their portion of the design, and to the completion of project tasks. Make a list of the most important items, and then describe the learning strategies you will use to accomplish each item.

* Describe any independent search or research that you plan to perform, and what sources or resources you think might be helpful.
* Will you consult with experts from the faculty, industry, or elsewhere? If so, describe who these experts will be, or how you plan to go about finding them.

## Team Member 2

Follow a similar format for each team member, and remember that it is important here to distinguish between them. Focus on the non-overlapping responsibilities, as opposed to those that multiple team members will share.

# Schedule and Budget Plan

## Project Schedule

Develop a schedule for your project. Describe in detail what each team member will accomplish each week between now and the end of the semester. An important element here is sequencing: which tasks must be completed sequentially, because one is dependent on the completion of the other, and which can be completed in parallel? Make sure that everyone has plenty of work to do every week, and that you will complete all of the milestones by the due dates.

Make sure that your schedule has you finishing the prototype, with **all** design and construction completed, at least two weeks before the end of the term. You need this time to design and conduct experiments to evaluate your prototype, and collect and analyze the data from those experiments.

## Project Budget

Also clearly reveal your plan to spend the allowed budget of $200 to purchase all the components that what you will to complete the prototype. Your first graded checkoff will occur shortly, after that checkoff you will be evaluated/graded on your progress every other week.

* List the items you plan to acquire for your initial order
* Provide proper justification for your order and explain how it moves the project forward.
* You have a nominal overall project budget of about $200.
* After the 1st checkoff, you will be given an opportunity to re-evaluate your schedule and be given the opportunity to order more/different parts. You do not have to order all the items you may need for your prototype now, especially if you will not make use of them over the next two weeks.

## Minimum Standard for Project Completion

In this section, propose a minimum standard for project completion. You may be planning on incorporating many features into your design. However, there may be difficulty in successfully demonstrating some of what you proposed. Please propose a minimum standard for completion. We will use this as a basis for an agreement between team and instructor.

Think of this as the ‘worst case scenario’, not the best-case (i.e. What is required to assign a passing grade for the project? - Not the minimum demonstration for a good grade, but minimum for a passing grade).

## Final Demonstration

You will be required to demonstrate your working prototype to the instructors, and show them the data from your testing. In this section please describe what you will demonstrate, and what test results you expect to show. This is quite different from the minimum standard for completion, but rather all of the features on which you expect to be graded and evaluated.

# References

Provide a list of references used in your design project. Many of these, if not all, will be cited in the Background section of your report, but you should also cite them wherever you make use of information you obtained from them.