A picture containing graphical user interface

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CS-25-334-llms-for-clinical-notes

Project Proposal

Prepared for

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**Executive Summary**

The executive summary highlights the key points of the document. While your advisor(s) and sponsor are expected to read the document in detail, others may only read the summary looking for a brief overview of the report. Casual readers may look at the summary to decide if they would like to continue reading. Some, more senior decision makers (e.g. executives), may read the summary to help make decisions regarding the future of the project (e.g. continuation, financing, resource allocation, etc.). It is important that all readers get a complete sense of the project, including purpose, primary objectives, design requirements, deliverables, work done to date, and timeline, among other required components provided in a table of contents. Summaries should be considered as “stand-alone” containing a complete account of the essential points of the document in chronological order of the document. Particular focus should be placed on the first sentence in order to draw readers in and should explicitly include the “who, what, and why” of the project. The executive summary is usually between half a page and a full page.

**Note:** The Executive Summary should be updated between major reports as more knowledge is acquired and understanding of the project expands. For example, when submitting Preliminary Design Report in December 2024, make sure you update this page to reflect the progress on the project since the submission of Project Proposal in early October 2024.

**Table of Contents**

[Section A. Problem Statement 5](#_Toc176438097)

[Section B. Engineering Design Requirements 7](#_Toc176438098)

[B.1 Project Goals (i.e. Client Needs) 7](#_Toc176438099)

[B.2 Design Objectives 7](#_Toc176438100)

[B.3 Design Specifications and Constraints 8](#_Toc176438101)

[B.4 Codes and Standards 9](#_Toc176438102)

[Section C. Scope of Work 11](#_Toc176438103)

[C.1 Deliverables 11](#_Toc176438104)

[C.2 Milestones 12](#_Toc176438105)

[C.3 Resources 12](#_Toc176438106)

[Section D. Concept Generation 13](#_Toc176438107)

[Section E. Concept Evaluation and Selection 14](#_Toc176438108)

[Section F. Design Methodology 16](#_Toc176438109)

[F.1 Computational Methods (e.g. FEA or CFD Modeling, example sub-section) 16](#_Toc176438110)

[F.2 Experimental Methods (example subsection) 16](#_Toc176438111)

[F.5 Validation Procedure 16](#_Toc176438112)

[Section G. Results and Design Details 18](#_Toc176438113)

[G.1 Modeling Results (example subsection) 18](#_Toc176438114)

[G.2 Experimental Results (example subsection) 18](#_Toc176438115)

[G.3 Prototyping and Testing Results (example subsection) 18](#_Toc176438116)

[G.4. Final Design Details/Specifications (example subsection) 18](#_Toc176438117)

[Section H. Societal Impacts of Design 20](#_Toc176438118)

[H.1 Public Health, Safety, and Welfare 20](#_Toc176438119)

[H.2 Societal Impacts 20](#_Toc176438120)

[H.3 Political/Regulatory Impacts 20](#_Toc176438121)

[H.4. Economic Impacts 20](#_Toc176438122)

[H.5 Environmental Impacts 21](#_Toc176438123)

[H.6 Global Impacts 21](#_Toc176438124)

[H.7. Ethical Considerations 21](#_Toc176438125)

[Section I. Cost Analysis 22](#_Toc176438126)

[Section J. Conclusions and Recommendations 23](#_Toc176438127)

[Appendix 1: Project Timeline 24](#_Toc176438128)

[Appendix 2: Team Contract (i.e. Team Organization) 25](#_Toc176438129)

[Appendix 3: [Insert Appendix Title] 26](#_Toc176438130)

[References 27](#_Toc176438131)

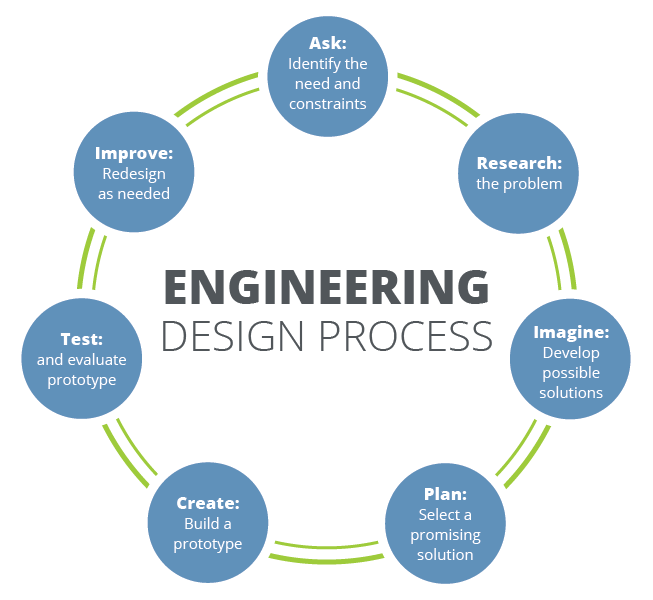
### Section A. Problem Statement

Before a design solution is proposed, it is first important to identify, define, and fully understand the problem. Through a significant research effort, provide all relevant background information needed to understand the reasons for doing the project and the **unmet engineering need(s)** being addressed by the project. Assume that the reader does not have existing knowledge of the problem. Some questions that may be addressed by the problem statement include who is facing the problem and why? How widespread (i.e. common) is the problem? How often does the problem occur? What are the potential costs associated with the problem (e.g. economic, environmental, societal, health and safety, etc.)? Who is the project client? Who are the stakeholders? The problem statement should be narrative in nature. It should provide a framework for the project and clearly convey the primary goal(s) of the project.

Discuss the general field of study or industry that the project falls under and how the project contributes to, or advances the current technology in that field. For industry sponsored projects, a brief introduction of the sponsor company and relevant product line(s) is appropriate. For faculty sponsored projects, a description of the laboratory and type of work performed in the lab is appropriate. Put the current project into historical perspective using external references. Determine if the problem, or a closely related problem, has previously been addressed. If so, summarize the results, including any relevant data and/or conclusions, and discuss how this project improves or builds on previous results. For industrial projects, see what non-sensitive information about the process or product line your sponsor will provide. Look for commercially available competitive designs, relevant patents, and alternative design options. For academic studies, search for published journal articles in the field of study. See what papers have been published leading up to the current project. Looking at an article’s references may provide additional lines of references. What are the pros and cons of each prior solution attempt?

Figures can often help aid in the discussion and understanding of technical subject matter. Examples of figures may include a labeled, detailed mechanical drawing, 3D rendering, photograph, schematic, process flow chart, etc. All figures should include a figure number and title located below each figure, and a reference number if necessary. The introduction should include a minimum of 5 cited references. More are encouraged. All references should be cited in-text and on a reference page at the end of the report using the APA citation format [1]. Figure 1, illustrating the engineering design process, provides an example of a properly labeled and cited imaged. Given the level of investigative detail required for this design report, it is expected that the introduction will consist of several pages.

***Note:*** The problem statement should be updated between major reports as more knowledge is acquired and understanding of the project expands.



**Figure 1. The iterative nature of the engineering design process [2].**

### Section B. Engineering Design Requirements

This section describes the goals and objectives of the project, as well as all **realistic constraints** to which the design is bound. It is meant to provide a structure that helps to formulate the problem. Design requirements are often derived from client or stakeholder needs. They may consider benchmarking against or improving on currently available solutions, providing novel techniques or design solutions, integration with existing components, systems, or equipment, required codes and standards, general observations of the problem space, etc. Describe how the requirements provided below were researched and decided upon. Common design requirements often include considerations of the design efficacy, cost, safety, reliability, usability, and risk, among others.

***Note:*** The deign requirements should be revisited between major reports to ensure that the design objectives and constraints still accurately reflect the client needs and project goals and to make sure that the team is on track to meet all goals and objectives.

***Note:*** The codes and standards section is not required for the Project Proposal, but is required for all subsequent reports. This section should be comprehensive and thorough, requiring a significant research effort.

#### B.1 Project Goals (i.e. Client Needs)

Describe the overall goals of the project from the point of view of the customer or client. Goals should be derived from the specified needs of the project and *do not explicitly describe what the design will do*. They should be short, concise, and achievable. Bulleted lists are a good way to present key points and draw the reader’s attention to those points. Note that a few sentences should be included at the beginning of any section using a bulleted list to introduce the content of the section and lead into the upcoming list. Some general examples of project goals are as follows:

* To produce an improved method for achieving some function
* To design a smaller, cheaper, faster, etc. device that performs some function
* To perform an experiment to produce data to gain a better understanding of some phenomena
* To produce a model that more accurately predicts some physical behavior

#### B.2 Design Objectives

List the key objectives of the design that you will produce. Objectives describe *what* *the design will do*, not how it should do it. Objectives should be SMART – Specific, Measurable, Achievable, Realistic, and Time-bound. Each objective will ultimately be linked to a design specification/constrain during the design process. Again, lists are nice if applicable.

* The design will…be specific.
* The design will…make sure the objective has the ability to be measured.
* The design will…make sure the objective is achievable given your resources.
* The design will…make sure the objective is realistic.
* The design will…make sure you have a reasonable time to achieve the objective.

#### B.3 Design Specifications and Constraints

A list of design specifications and constraints include all limitations, restrictions, and requirements of the design. They are firm limits that must be met for a design to be acceptable and are ultimately used to measure the success of a design. Each specification or constraint should map to one or more design objective(s) and explicitly state *how the design* will meet the objectives. Specifications and constraints should be specific and are often numerical. They must be measurable or testable to prove that the design has met all of the design objectives. Numerical metrics may include qualifying statements such as “at least,” “at most,” “between,” “exactly” or include a set of discrete values. Avoid subjective, untestable constraints (e.g. “environmentally friendly”, “user friendly”, “nice looking”, etc.).

**Realistic constraints** can come take on a variety of forms including accessibility, aesthetics, codes, constructability, cost, ergonomics, extensibility, functionality, interoperability, legal considerations, maintainability, manufacturability, marketability, policy, regulations, schedule, standards, sustainability, or usability. Examples of physical constraints might include numerical limits or ranges on overall size envelope, weight, pressures, stresses, flow rates, voltages, current, power consumption, hardware limitations, data constrains, interoperability, etc. Other constraints might include production unit cost, expected part/device life, or maintenance requirements.

Some general examples of constraints are as follows:

* Design must integrate with existing equipment or process (Functional constraint) – examples include specific piping or electrical connections, available size envelope, power requirements, etc.
* Design must not exceed some overall weight (Functional constraint) – specify weight limits or range
* Design must not exceed some power consumption or operate at some efficiency (Functional constraint) – examples include current, voltage, power requirements, mechanical or electrical efficiency
* Must be cheaper to produce than currently available designs (Cost constraint) – provide specific cost limit or range
* Design must be made from readily available materials (Manufacturability constraint) – provide exact materials
* Design must operate for so many hours without requiring maintenance (Maintainability constraint) – provide exact time or range
* Design must operate within some hardware with specifications up to certain values (Hardware constraint) – provide exact hardware specifications
* Design must operate within some constrains on data collection and processing (Data Constrains) – provide exact guidelines or restrictions
* Design must operate within a set of systems or platforms requiring compatibility with specific protocols or APIs (Interoperability Constrains) – provide specific systems of platforms.

#### B.4 Codes and Standards

List all specific codes and standards that are relevant to the design providing specific details of each as they relate to the design. While the terms codes and standards are often used interchangeably, there are in fact important differences in their definitions that should be understood. **Standards** are documents that provide a set of technical definitions, instructions, rules, guidelines and/or characteristics of a product, process, or service meant to provide consistent and comparable results (e.g. performance requirements, dimensions, testing procedures, file formats etc.). They allow for interchangeability of components and system interoperability and are typically produced by industry or professional organizations such as ASME, ANSI, ASTM, IEEE, ISO, ACM, IAPP, AIS, etc. Standards are meant to help ensure quality, reliability, and safety.

**Codes** are laws or regulations that specify the methods, materials, components, etc. required for use in a certain product, process, or structure. Codes have been *codified* into a formal written policy or law and can be approved at the local (municipal), state, or federal level. While standards provide sets of guidelines, codes are constraints that *must* be met in accordance with the law. It is, however, common for codes to reference or require the use of one or more standards. Some common code producers include the EPA, OSHA, DOTs, and the NFPA. Codes help set minimum acceptable levels in order to protect public health, safety, welfare.

Codes and standards are often listed by their producer followed by an identifying numerical code. They often contain hyphens or periods which may help reference specific parts of a larger code/standard or provide the year of the latest revision. Some general examples in a list of codes and standards are as follows:

* ASME Standard No. xxx – design must consider some specific fatigue failure criteria
* IEEE Standard No. xxx – design components must not exceed some maximum current limit
* ISO Standard No. xxx – design components must adhere to some standard thread size
* OSHA Code No. xxx – operators of design must wear appropriate eye and face protection
* IRTF Standard No. xxx – design must consider internet communication protocols
* W3C Standard No. xxx – design must adhere to some HTML/CSS standards
* NIST Standard No. xxx – design must consider some specific data security standards

***Note:*** Relevant codes and standards should be incorporated into the design specifications and constraints listed above.

### Section C. Scope of Work

The project scope defines the boundaries of the project encompassing the key objectives, timeline, milestones and deliverables. It clearly defines the responsibility of the team and the process by which the proposed work will be verified and approved. A clear scope helps to facilitate understanding of the project, reduce ambiguities and risk, and manage expectations. In addition to stating the responsibilities of the team, it should also explicitly state those tasks which fall *outside* of the team’s responsibilities. *Explicit bounds* on the project timeline, available funds, and promised deliverables should be clearly stated. These boundaries help to avoid *scope creep*, or changes to the scope of the project without any control. This section also defines the project approach, the development methodology used in developing the solution, such as waterfall or agile (shall be chosen in concert with the faculty advisor and/or project sponsor). Good communication with the project sponsor and faculty advisor is the most effective way to stay within scope and make sure all objectives and deliverables are met on time and on budget.

#### C.1 Deliverables

The project deliverables are those things that the project team is responsible for providing to the project sponsor. They are the things that are to be produced or provided as a result of the engineering design process. Some deliverables might include a specific number of alternative designs, required analyses to prove the design meets specifications, detailed machine drawings, functional diagrams or schematics, required computer code, flow charts, user manuals, desktop models, and functioning prototypes. A design “proof of concept” is not specific and should be more clearly defined. Academic deliverables include the team contract, project proposal, preliminary design report, fall poster and presentation, final design report, and Capstone EXPO poster and presentation. Provide a bulleted list of all agreed upon project deliverables.

In order to mitigate risks associated with the completion and delivery of the project deliverables, provide an outline of the most potentially disruptive, foreseeable obstacles. Some important issues to discuss with the design team, sponsor, and faculty advisor include the following:

* What deliverables require access to campus? Which/how many students regularly access campus and are physically available to complete tasks?
* What work can be done remotely? What resources might be needed in order to ensure that remote work can be completed effectively (e.g. software licenses, shared drives/folders, etc.)?
* What deliverables require ordering from third-party vendors? Will any components potentially required extended lead times? What can the team do in order to mitigate potential supply chain disruptions?

#### C.2 Milestones

Milestones are major project phases or tasks that need to be completed in order to ensure the project deliverables. They may include, among other things, completion of calculations, the development of a computational model, completion of an analysis, set-up of an experiment, completion of data acquisition, purchasing of hardware, assembly of a prototype, completion of testing procedures, development of required code, completion of wiring, post processing, etc.

A good rule of thumb is to break the project down into tasks of no larger than 2-3 weeks in length. These can be individual or group tasks. Breaking down the project into tasks/milestones gives the team and the advisor/sponsor a realistic understanding of what can be done in the allotted time. In an agile development approach, later tasks are expected to be adjusted (or changed) as the team works with the earlier developed tasks.

The amount of time it will take to accomplish each milestone and the approximate date that each milestone will be completed should be considered. Do not underestimate the time that it takes to write and prepare major reports and presentation materials. All deliverables and milestones should be included in the project timeline found in Appendix 1. Provide a summary table of all project milestones including required times and completion dates here.

***Note:*** While the project scope, deliverable, and milestones are not intended to change throughout the project, this section should be revisited between major reports to ensure that it still accurately reflects the expectations and requirements of the project team, client, and faculty advisor. Any changes to the project scope, deliverable, and milestones should be thoroughly discussed and mutually agreed upon by all parties. Any changes to this section should be documented and justified in detail.

#### C.3 Resources

Resources needed for project completion should be listed at the proposal stage. These resources can either be purchased within the Project Budget, or provided by the project sponsor. Some examples are: hardware such as HPCs or servers, software such as IDEs, data analysis platforms or version control systems. Access to cloud computing services may also be necessary to scale certain procedures. Additionally, databases containing operational data for testing, as well as libraries or APIs relevant to predictive analytics and machine learning may be required.

### Section D. Concept Generation

A number of methods can be used to help generate design concepts from simple reflection and brainstorming, to working the problem backwards, using reverse thinking techniques, and looking to nature for inspiration (i.e. biomimicry). Existing solutions, or components of existing solutions, can be substituted, combined, adapted, modified, put to other uses, eliminated, or rearranged to meet new design objectives and specifications. A minimum of 3 overall design concepts is required for this section although more are welcome. Provide a brief description of how each design concept addresses the design problem. Discuss the potential pros and cons, including and potential risks of failure, of each of these concepts.

It is likely that each design concept may consist of several components. In this case, one or more of these components may offer a sub-problem that can be further explored, modified, or otherwise improved upon. These sub-problems may lead to the addition of several additional design concepts and may require the inclusion of a design concept chart or matrix to organize all ideas and potential solutions.

Provide any initial design sketches, drawings, 3D renderings, or conceptual models such as dataflow diagrams, process flows, etc. developed during the concept ideation phase. All hand drawings should be drawn to scale using basic engineering drafting tools (i.e. ruler, protractor, and compass). Geometric stencils can also be used to help produce quality hand drawings. Drawings should be presented in a profession manner, preferably done on engineering graph paper and using a high-quality scan. All sketches should be labeled to identify major components and different drawing views or projections if applicable. Basic dimensions should be provided to give a general sense of scale. Label each sketch or drawing with the name of the team member responsible for the sketch, the date it was drawn, and the drawing scale.

### Section E. Concept Evaluation and Selection

Using a systematic decision-making process, evaluate each of the design concepts and choose the one that is most likely to succeed in meeting the design objectives and constraints. A Decision Matrix, or Pugh Matrix, helps to analyze alternatives, eliminate biases, and make rational decisions through thought and structure. First, work to develop a set of selection criteria for which to evaluate the previously generated design concepts. Selection criteria often include concepts of performance, cost, safety, reliability, risk, etc. Note that the selection criteria developed here will likely be more general than the project design objectives. As with the design objectives, conversations with the client help define appropriate selection criteria.

In many cases, the client may value the selection criteria differently, preferring that more emphasis be placed on some than others. In this case, weighting factors may be used to place more or less importance on the various criteria in the decision making process. Again, conversations with the client can be used to define criteria weighting factors. Often times, these conversations must be analyzed and interpreted by the team to determine which criteria are more important to the client and by how much. Feel free to discuss the assigned weighting factors with the client to see if they seem accurate.

Next, define an associated metric to represent each criteria. Metrics should be specific and quantifiable, providing numerical values that quantify the often vague concepts of the selection criteria. Metrics can be obtained, generated, or estimated through a number of methods including simple background research, preliminary design calculations, or basic analyses. Note that these metrics do not need to specifically align with the design specifications although there may be some commonality between the two. Provide a brief discussion of the rationale for selecting each of the assigned metrics.

Using the defined metrics, evaluated each design concept against all selection criteria by filling out a Decision Matrix. Design concepts can be compared by using simple rank scoring, raw scoring, or weighted scoring techniques and design concept with which to move forward can be selected. This type of process provides a meaningful, unbiased means for choosing a preliminary design concept prior to moving forward with more comprehensive, detailed analyses as provided in the design methodology section below. The results of this process should be discussed with the project client prior to moving forward with the selected design. Table 1 provides an example of a simple decision matrix.

**Table 1. Example of a Decision Matrix.**



***Note:*** Weights can be assigned to each criterion if desired.

### Section F. Design Methodology

Provide a detailed explanation of the methods that will be used to help evaluate, improve, and evolve the design through the iterative engineering design process. Consider that ultimately, the final design must be verified and validated to ensure that it meets all of the previously developed and listed design objectives and specifications. Verification ensures that the design meets all specification, while validation confirms that the design functions as intended such to meet the client’s needs. While it is common for initial design concepts to first be evaluated using simplified design criteria and metrics, the chosen design should be advanced, and later verified, using engineering calculations, computational models, experimental data, and/or testing procedures.

Use this section to describe any underlying physical principles and mathematical equations that govern the design. Provide details of any computer-aided modeling techniques used to evaluate the design including the software used, prescribed boundary conditions, and assumptions. Include a detailed description of any experimental testing methods including required testing equipment, test set-up layout, data acquisition and instrumentation, and testing procedures. If one or more prototypes is to be produced and tested, provide a detailed description of how each will be evaluated.

**Note:** The contents of this section are expected to vary from project to project. Subsections may be appropriate for providing details of analytical, computational, experimental, and/or testing methods. Some potential subsections that may be included in this section are provided. While critical design equations may be provided here, lengthy mathematical derivations may be included in an appendix. Validation procedures are critical and all projects should address such topic.

#### F.1 Computational Methods (e.g. FEA or CFD Modeling, example sub-section)

#### F.2 Experimental Methods (example subsection)

**F.3 Architecture/High-level Design (example subsection)**

#### F.5 Validation Procedure

Describe how the design team will validate that the final design meets the client’s needs. This section should include a plan to meet with the client towards the end of the project to discuss final design details and demonstrate a prototype, experimental test, and/or simulation results. Provide a relative time frame for this validation to occur (e.g. “mid-March” or “early-April”). Include a brief discussion on how client feedback will be captured, such as a formal survey, interview, or observation notes of the client using the prototype. It may also include plans to solicit feedback from other stakeholders and/or potential users.

### Section G. Results and Design Details

Use this section to highlight the major results of the design methodology described above including important analytical, computational, experimental, modeling, assembly, and testing results. This section should be one of the most substantial sections of the report showcasing all of the hard work and effort that went into the completion of the final design and delivery of the project deliverables. Show how the identified problem was solved.

Highlight the prominent features of the final design through analysis results, modeling, drawings, renderings, circuit schematics, instrumentation diagrams, flow and piping diagrams, etc. to show that the design functions as intended and meets all design objectives and constraints. Overview designs such as dataflow diagrams, process flow, swim lane diagrams, as well as presentation-layer designs (e.g. storyboards for front-ends) should be included here. Detailed designs such as database designs, software designs, procedure flowcharts, or pseudocode should be included here. Support computational and experimental results with key plots and figures. All supporting figures should be clearly labeled and annotated to highlight the most important points of the figure (i.e. explicitly point out what the reader should focus on or understand about the image).

Note that while all results should be used to help inform design decisions, not all results may be necessary to include in the main body of the report. Extraneous supporting results (e.g. graphs, data, design renderings, drawings, etc.) that are not necessary for presenting the fundamental findings can be placed in one or more appendices. Detailed documentation of each program module can be provided as appendix.

#### G.1 Modeling Results (example subsection)

#### G.2 Experimental Results (example subsection)

#### G.3 Prototyping and Testing Results (example subsection)

#### G.4. Final Design Details/Specifications (example subsection)

Note that while the design constraints and specifications may have provided minimum or maximum values, or ranges or values, that the design needed to meet, the final design specifications should be listed here showing that the required design values were met. A list of final design details can also be included demonstrate fulfillment of the design objectives.

***Note:*** Preliminary results should be included in the Preliminary Design Report to show the progress made of the selected design concept to-date. This section should be updated for the Final Design Report to include documentation of all of the work that was completed on the project throughout the entirety of the academic year.

### Section H. Societal Impacts of Design

In addition to technical design considerations, contemporary engineers must consider the broader impacts that their design choices have on the world around them. These impacts include the consideration of public health, safety, and welfare as well as the potential societal, political/regulatory, economic, environmental, global, and ethical impacts of the design. As appropriate for the project design, discuss how each of these considerations influenced design choices in separate subsections. How will the design change the way people interact with each other? What are the political implications of the design? Does the technology have the potential to impact or shift markets? Does the design have any positive or negative effects on the environment? Don’t forget to consider unintended consequences such as process or manufacturing byproducts. What impacts might the design have on global markets and trade? Are there any ethical questions related to the design?

While it is hard to forecast the various impacts of a technology, it is important to consider these potential impacts throughout the engineering design process. When considered during the early stages of the design phase, consideration of these impacts can help determine design objectives, constraints, and specifications and help drive design choices that may mitigate any potential negative impacts or unintended consequences.

***Note:*** A minimum of 4 of these design considerations, including the consideration of public health, safety, and welfare, are required for the Preliminary Design Report while a section for all considerations must be included in the final design report.

#### H.1 Public Health, Safety, and Welfare

Provide a list of all design safety features and provide a brief description of each. Discuss the potential effects the design may have on public health, safety, and welfare. References to the codes and standards previous provided and the organizations that produced them may be summarized or referenced here.

#### H.2 Societal Impacts

#### H.3 Political/Regulatory Impacts

#### H.4. Economic Impacts

#### H.5 Environmental Impacts

#### H.6 Global Impacts

#### H.7. Ethical Considerations

### Section I. Cost Analysis

Provide a simple cost analysis of the project that includes a list of all expenditures related to the project. If an experimental test set-up or prototype was developed, provide a Bill of Materials that includes part numbers, vendor names, unit costs, quantity, total costs, delivery times, dates received, etc. Do not forget to include all manufacturing costs incurred throughout the completion of the project. If the design is expected to become a commercial product, provide a production cost estimate including fixed capital, raw materials, manufacturing (including tooling and/or casting), and labor costs to produce and package the device. Note that this type of detailed cost analysis may be listed as a project deliverable.

**Note:** The Preliminary Design Report should include all costs incurred to date. It is expected that this section will be expanded and updated between the preliminary and final design reports.

### Section J. Conclusions and Recommendations

Use this section to summarize the story of how the design team arrived at the final design. Focus on the evolution of the design through the use of the engineering design process including lessons learned, obstacles overcome, and triumphs of the final design. Revisit the primary project goals and objectives. Provide a brief summary of the final design details and features paramount to the function of the design in meeting these goals and objectives.

A discussion may be included to discuss how the design could be further advanced or improved in the future. If applicable, summarize any questions or curiosities that the final results/design of this effort bring to mind or leave unanswered. If this project might continue on as a future (continuation) senior design project, detail the major milestones that have been completed to date and include any suggested testing plans, relevant machine drawings, electrical schematics, developed computer code, etc. All relevant information should be included in this section such that future researchers could pick up the project and advance the work in as seamless a manner as possible. Documents such as drawings, schematics, and codes could be referenced here and included in one or more appendix. If digital files are critical for future work, they should be saved on a thumb drive, external hard drive, cloud, etc. and left in the hands of the project advisor and/or client.

### Appendix 1: Project Timeline

Provide a Gantt chart of similarly composed visual timeline showing the start and end dates of all completed tasks and how they are grouped together, overlapped, and linked together. Include all senior design requirements including design reports and Expo materials (i.e. Abstract, Poster, and Presentation). All major milestones should be included in the timeline.

### Appendix 2: Team Contract (i.e. Team Organization)

Copy and paste the content from the completed Team Contract here starting with Step 1 of the Team Contract and including all content following the ‘Contents’ list.

### Appendix 3: [Insert Appendix Title]

Note that additional appendices may be added as needed. Appendices are used for supplementary material considered or used in the design process but not necessary for understanding the fundamental design or results. Lengthy mathematical derivations, ancillary results (e.g. data sets, plots), and detailed mechanical drawings are examples of items that might be placed in an appendix. Multiple appendices may be used to delineate topics and can be labeled using letters or numbers. Each appendix should start on a new page. Reference each appendix and the information it contains in the main text of the report where appropriate.

***Note:*** Delete this page if no additional appendices are included.

### References

Provide a numbered list of all references in order of appearance using APA citation format. The reference page should begin on a new page as shown here.

[1] VCU Writing Center. (2021, September 8). *APA Citation: A guide to formatting in APA style.* Retrieved September 2, 2024. https://writing.vcu.edu/student-resources/apa-citations/

[2] Teach Engineering. *Engineering Design Process*. TeachEngineering.org. Retreived September 2, 2024. https://www.teachengineering.org/populartopics/designprocess