Project Title

DESIGN DOCUMENT

Team Number
Client(s)
Advisor(s)
Team Members/Roles
Team Email
Team Website

Executive Summary

Provide a brief (300-500 word) summary of your project. This summary should give the reader enough information to understand the purpose, design strategies, and project outcomes. It should address at least the following questions/items:

- What is the problem and why is it important?
- What were your design requirements?
- Summarize your design, include approaches and technologies used.
- How well does your design meet requirements and address user needs? How do you know?
- What are potential implications of your design or next steps to be taken?

Learning Summary

Development Standards & Practices Used

List all standard circuit, hardware, software practices used in this project. List all the engineering standards that apply to this project that were considered.

Summary of Requirements

List all requirements as bullet points in brief.

Applicable Courses from Iowa State University Curriculum

List all Iowa State University courses whose contents were applicable to your project.

New Skills/Knowledge acquired that was not taught in courses

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum in order to complete this project.

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List of figures/tables/symbols/definitions

1. Introduction

1.1. Problem Statement

What problem is your project trying to solve? This section should be written in paragraph form and tell the story of your design problem. Describe the broader user/societal/global context in which you're designing. What issues exist in that context? Why are they important? How are you attempting to address those issues?

You may find the Problem Statement Worksheet helpful in creating this narrative.

This section should be written for a non-engineering audience, so be engaging and use non-technical jargon as much as possible.

1.2. Intended Users

Who will use the product you create? Who benefits from or will be affected by the results of your project? List as many users or user groups as are relevant to your project (at least three). For each user or user group, (1) describe the user and their key characteristics (e.g., a persona), (2) identify their need(s) related to the project (e.g., a needs statement), and (3) discuss how they might benefit or derive value from the product you create. Justify how these benefits/this value connects to your overarching problem statement.

Please include any user research documentation, empathy maps, or other artifacts as appendices.

2. Requirements, Constraints, and Standards

2.1. Requirements & Constraints

List all requirements for your project. Separate your requirements by type, which may include functional requirements (specification), resource requirements, physical requirements, aesthetic requirements, user experiential requirements, economic/market requirements, environmental requirements, UI requirements, and any others relevant to your project. When a requirement is also a quantitative constraint, either separate it into a list of constraints, or annotate at the end of requirement as "**(constraint)**." Ensure your individual requirements are realistic, specific, and reflective or in support of user needs, and ensure your collective requirements are comprehensive.

2.2. Engineering Standards

What engineering standards apply to your project? Some standards might be built into your requirements (e.g., many projects use 802.11 ac wifi standard). Describe how you have incorporated specific relevant engineering standards into your project. Incorporating a standard means making design decisions based on the standard and clearly documenting its use in the design and implementation sections.

NOTE: The following activity may be helpful. You do not need to include the activity documentation in this report.

Q1) Browse the videos and interactive pages available at the IEEE Standards website:

https://standards.ieee.org/about/standards-in-action/

Select at least three videos and/or pages. These are generally short.

Briefly describe, in your own words, the importance of engineering standards.

Q2) Browse the IEEE Standards website, such as these pages:

https://standards.ieee.org/standard/

https://standards.ieee.org/products-programs/standards-related/interactive-standards/

Select a category appropriate for your project. Select at least 3 standards that appear, based on their descriptions, to have relevance to your project. Most of these standards can be found on the IEEE Xplore digital library (http://ieeexplore.ieee.org/Xplore/), which you have access to via the on-campus network. If off-campus, you can use the ISU VPN and library portal to get access (http://instr.iastate.libguides.com/ecpe/).

If your project requires *software standards*, review this source: https://www.iso.org/standards.html

Review each of the standards you selected. These can be quite lengthy documents, and you are not expected to read through them in their entirety.

Describe, in your own words, what each standard is about and what it is intended to accomplish.

Q3) After reviewing some of the technical details of the three selected standards, do you believe it has relevance to your project? Why or why not? Be specific.

Q4) Review with your team the standards that each of you have selected. What other standards did some of your team members choose that are different?

Q5) In what specific ways do you plan to incorporate these standards into the design and implementation of your project?

3. Project Plan

3.1. Project Management/Tracking Procedures

What project management style have you adopted (e.g., agile, waterfall, or waterfall+agile)? Justify your project management style with respect to the project goals and contexts.

Also, describe how your team will track progress throughout the course of this and the next semester. This could include Git, Github, Trello, Slack or any other tools helpful in project management.

3.2. Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and subtasks and to understand interdependence among tasks. This step might be useful even if you adopt agile methodology. If you are agile, you can also provide a linear progression of completed requirements aligned with your sprints for the entire project.

3.3. Project Proposed Milestones, Metrics, and Evaluation Criteria

What are some key milestones in your proposed project? It may be helpful to develop these milestones for each task and subtask from 3.2. How do you measure progress on a given task? These metrics, preferably quantifiable, should be developed for each task. The milestones should be stated in terms of these metrics: Machine learning algorithm XYZ will classify with 80% accuracy; the pattern recognition logic on FPGA will recognize a pattern every 1 ms (at 1K patterns/sec throughput). ML accuracy target might go up to 90% from 80%.

In an agile development process, these milestones can be refined with successive iterations/sprints (perhaps a subset of your requirements applicable to those sprint).

3.4. Project Timeline/Schedule

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.2) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development model. For agile, a sprint schedule with specific technical milestones/requirements/targets will work.

3.5. Risks and Risk Management/Mitigation

For each task, identify all salient risks (certain performance target may not be met; certain tool may not work as expected) and assign an educated guess of probability for that risk. For any risk factor with a probability exceeding 0.5 and each high severity risk, develop a risk mitigation plan. Can you eliminate that task and add another task or set of tasks that might cost more? Can you buy something off-the-shelf from the market to achieve that functionality? Can you try an alternative tool, technology, algorithm, or board?

Agile project can associate risks and risk mitigation with each sprint.

Discuss the risks that came to pass (whether you previously identified them or did not). Describe how each occurred and how your responded to the event/outcome.

3.6. Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be the projected effort in total number of person-hours required to perform the task. Create a separate table documenting actual personnel effort requirements. Briefly discuss any substantial mismatch between estimates and actual effort.

3.7. Other Resource Requirements

Identify the other resources aside from financial (such as parts and materials) that were required to complete the project.

4. Design

4.1. Design Context

4.1.1 Broader Context

Describe the broader context in which your design problem is situated. What communities are you designing for? What communities are affected by your design? What societal needs does your project address? Update this table based on new developments in your project or additional context elements you identified.

List relevant considerations related to your project in each of the following areas:

Area	Description	Examples
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct	Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing

	users or may be indirectly affected (e.g., solution is implemented in their communities)	safety risks, increasing/reducing job opportunities
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing usage/production of non-recyclable materials
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization

4.1.2 Prior Work/Solutions

Include relevant background/literature review for the project (cite at least 3 references for literature review in IEEE Format. See link: https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf)

– If similar products exist in the market, describe what has already been done

– If you are following previous work (e.g., a previous senior design project), cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available. Thus, provide a list of pros and cons of your target solution compared to all other related products/systems.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

4.1.3 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

4.2. Design Exploration

4.2.1 Design Decisions

List key design decisions (at least three) that you made. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe how you made these decisions and how they affected success.

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.

4.2.3 Decision-Making and Trade-Offs

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

4.3. Final Design

4.3.1 Overview

Provide a high-level description of your final design. This description should be understandable to non-engineers (i.e., the general public). Describe key components or sub-systems and how they contribute to the overall design. You may wish to include a basic block diagram, infographic, or other visual to help communicate the overall design.

4.3.2 Detailed Design and Visual(s)

Provide a detailed, technical description of your design, aided by visualizations. This description should be understandable to peer engineers. In other words, it should be clearly written and sufficiently detail such that another senior design team can look through it and implement it.

The description should include a high-level overview written for peer engineers. This should list all subsystems or components, their role in the whole system, and how they will be integrated or interconnected. A visual should accompany this description. Typically, a detailed block diagram will suffice, but other visual forms can be acceptable.

The description should also include more specific descriptions of subsystems and components (e.g., their internal operations). Once again, a good rule of thumb is: could another engineer with similar expertise build the component/sub-system based on your description? Use visualizations to support your descriptions. Different visual types may be relevant to different types of projects, components, or subsystems. You may include, but are not limited to: block diagrams, circuit diagrams, sketches/pictures of physical components and their operation, wireframes, etc.

The description should describe if and how you incorporated any specific relevant engineering standard(s) in your project. Incorporating a standard means making design decisions based on the standard and clearly documenting its use in the design section, as appropriate.

4.3.3 Functionality

Describe how your design operates in its user and/or real-world context. What does a user do? How does the device/system/etc. respond? This description can be supplemented by a visual, such as a timeline, storyboard, or sketch.

4.3.4 Areas of Challenge

What challenges did you face in completing your design, with regard to both technical progress? satisfying requirements, and meeting user needs?

How did you overcome or address those challenges?

4.4. Technology Considerations

Describe the distinct technologies you are using in your design. Highlight the strengths, weaknesses, and trade-offs in technologies available.

5. Testing

Testing is an **extremely** important component of all projects, whether it involves a circuit, a process, power system, or software.

The testing plan should connect the requirements and the design to the adopted test strategy and instruments. In this overarching introduction, given an overview of the testing strategy and your team's overall testing philosophy. Emphasize any unique challenges to testing for your system/design.

In the sections below, describe specific methods for testing. You may include additional types of testing, if applicable to your design. If a particular type of testing is not applicable to your project, you must justify why you are not including it.

When writing your testing plan consider a few guidelines:

- Is our testing plan unique to our project? (It should be)
- Are you testing related to all requirements? For requirements you're not testing (e.g., cost related requirements) can you justify their exclusion?
- Is your testing plan comprehensive?
- When should you be testing? (In most cases, it's early and often, not at the end of the project)

5.1. Unit Testing

What units were tested? How were they tests? What tools did you use?

5.2. Interface Testing

What are the interfaces in your design? Discuss how the composition of two or more units (interfaces) were tested and what tools you used.

5.3. Integration Testing

What are the critical integration paths in your design? Justification for criticality may come from your requirements. How were they tested? With which tools?

5.4. System Testing

Describe system level testing strategy. What set of unit tests, interface tests, and integration tests suffice for system level testing? This should be closely tied to the requirements. Tools?

5.5. Regression Testing

How did you ensure that any new additions do not break the old functionality? What implemented critical features did you need to ensure do not break? Is it driven by requirements? Tools?

5.6. Acceptance Testing

How did you demonstrate that the design requirements, both functional and non-functional, were being met? How did you involve your client in the acceptance testing?

5.7. Security Testing (if applicable)

How did you demonstrate that the security requirements, if any, were being met? What data and/or resources were protected? What security testing principles, methods, and/or tools were applied?

5.8. User Testing

How did you test whether your design addresses user needs? How did you involve your users? What were their reactions? What were your observations of users interacting with your design?

5.9. Testing Results

What are the results of your testing? Include any numerical, graphical, or qualitative testing results. Include testing results that pertain to engineering standards and constraints that were central to your project. Include a summary narrative that discusses key results and demonstrates how well your project addresses requirements and user needs.

6. Implementation

Describe what you have built, implemented, constructed, deployed, etc. How does this match your final design? What features, functions, and subsystems have been implemented? What features, functions, and subsystems were you unable to complete? Why were you unable to complete them?

The description should describe if and how your implementation adheres to specific relevant engineering standard(s) in your project, as appropriate.

6.1. Design Analysis

Discuss how well your implemented design works? Describe what works well. Why does it work well? What evidence do you have to demonstrate that?

Describe what does not work well or work as expected. Why? What could you have done differently?

7. Ethics and Professional Responsibility

Use this section to describe your considerations of engineering ethics and professional responsibility. Most importantly how are you defining engineering ethics and professional responsibility in the context of your project and what steps have you taken to ensure ethical and responsible conduct. Each section references one type of ethical/professional responsibility considerations. You may also use this introductory section to note any overarching ethical philosophy among your team. Be sure to update this section based on new developments in your project and personal ethical practice/awareness. If nothing has changed (which is doubtful), include a short description of why nothing has changed.

7.1. Areas of Professional Responsibility/Codes of Ethics

This discussion is with respect to the paper by J. McCormack and colleagues titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

Pick one of IEEE, ACM, or SE code of ethics (all linked in class slides). Create a table, like Table 1 in the McCormack et al. (2012, pg. 418)) paper, with the following columns representing: Area of Responsibility (from the paper), Definition (in your own words), Relevant Item from Code of Ethics (from the Code of Ethics you selected, and description of how your team has interacted with that area of professional responsibility or adhered to that code during your project thus far.

In text below the table, describe one area in which your team has performed well. Describe what your team has done and how that signifies strong performance. Also describe one area in which your team did not perform well. Describe what your team did that signified non-ideal performance and what you can do as individuals to improve in the future.

7.2. Four Principles

Create a table with rows for each broader context area (see Section 4.1.1) and columns for each of the four principles (beneficence, nonmalificence, respect for autonomy, and justice; see Beauchamp, 2007). Within the table, identify at least one way each of the four principles applies to each of the broader context areas. Some principle-broader context connections might be more prominent than others, but you should be able to identify something for each table cell. Note: Your design may have ended up negative or neutral in some cell. For example, your product might perform poorly in environment-nonmaleficence because it utilizes natural resources without a positive/mitigating effect.

Below the table, note one broader context-principle pair that is important to your project. Briefly describe the benefit in that area you have worked towards and how you achieved it. Also note one broader context-principle pair in which your project/end design is lacking. Describe either (a) how this negative is overcome by other positives in other areas of the project/design or (b) what your team could do to improve in this area in the future.

7.3. Virtues

List and define at least three virtues that are important to your team. Describe what you will do or have done as a team to support these virtues among all team members.

Each team member should also answer the following:

- Identify one virtue you have demonstrated in your senior design work? (Individual)
    - Why is it important to you?
    - How have you demonstrated it?
- Identify one virtue that is important to you that you have not demonstrated in your senior design work thus far? (Individual)
    - Why is it important to you?
    - What might you do to demonstrate that virtue?

8. Conclusions

8.1. Summary of Progress

Discuss the results of your project (i.e., the design you've developed/constructed, testing you've completed). Highlight your team's accomplishments and how well those addressed overall project goals.

8.2. Value Provided

Consider your design in context. How well does it address your users' needs? How well does it address the problems you set out to address. How well does it fit in the broader context? Provide examples of the value your design provides or could provide along with evidence of your assertions.

8.3. Next Steps

While your work on this project may be coming to a close, consider future work and follow-up projects. Discuss the next steps you would want to take or see other teams takes and why those next steps are important. These could include adding functionality you did not have time to implement or that is now possible based on your team's accomplishments. These could be follow-up projects in a larger design sequence. These could be new projects based on user needs or societal issues.

9. References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE). See link:

https://ieee-dataport.org/sites/default/files/analysis/27/IEEE%20Citation%20Guidelines.pdf

10. Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics/layout, PCB testing issues, software bugs, etc.

10.1. Appendix 1 – Operation Manual

- At least 2-3 pages
- Step-by-step instructions on how to setup/demo/test/use the system

10.2. Appendix 2 – Alternative/initial version of design

- Versions considered before client's specifications have changed
- Versions considered before learning more about the project
- Versions that resulted in failure to achieve specifications, etc.
- Describe each major design version and why they were scrapped/revised

10.3. Appendix 3 – Other considerations

- Any miscellany you deem important, what you learned, anything funny, anecdotes from your project experience

10.4. Appendix 4 – Code

- Include your GitHub repository link, snippets of code, etc.

10.5. Appendix 5 – Team Contract

Complete each section as completely and concisely as possible. We strongly recommend using tables or bulleted lists when applicable.

Team Members

Required Skill Sets for Your Project

If feasible – tie them to the requirements.

Skill Sets Covered by the Team

For each skill, state who covers it.

Project Management Style Adopted by the team

Typically, waterfall, agile, or hybrid for project management.

Individual Project Management Roles

Enumerate which team member plays what role.

Team Contract

Team Members:

1) _____ 2) _____

3) _____ 4) _____

5) _____ 6) _____

7) _____ 8) _____

Team Procedures

1) Day, time, and location (face-to-face or virtual) for regular team meetings:
2) Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):
3) Decision-making policy (e.g., consensus, majority vote):
4) Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:
2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:
3. Expected level of communication with other team members:
4. Expected level of commitment to team decisions and tasks:

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
2. Strategies for supporting and guiding the work of all team members:

3. Strategies for recognizing the contributions of all team members:

Collaboration

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.
2. Strategies for encouraging and support contributions and ideas from all team members:
3. Procedures for identifying and resolving collaboration or contribution issues (e.g., how will a team member inform the team that the team environment is impeding their opportunity or ability to contribute?)

Goal-Setting, Planning, and Execution

1. Team goals for this semester:
2. Strategies for planning and assigning individual and team work:
3. Strategies for keeping on task:

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?
2. What will your team do if the infractions continue?

****

a. I participated in formulating the standards, roles, and procedures as stated in this contract.
b. I understand that I am obligated to abide by these terms and conditions.
c. I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) _____ DATE _____

2) _____ DATE _____

3) _____ DATE _____

4) _____ DATE _____

5) _____ DATE _____

6) _____ DATE _____

7) _____ DATE _____

8) _____ DATE _____