University of Pittsburgh

ECE 1896: Senior Design

Introduction to Engineering Design

University of Pittsburgh
Swanson School of Engineering
Department of Electrical and Computer Engineering

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Outline

- **Module #1: Introduction to Engineering Design**
  - **Description of the Engineering Design Problem**
  - **Elements of the Engineering Design Problem**

- **Module #2: Conceptual Design Document**
  - **Assignment #3**

Description of the Engineering Design Problem

- Design thinking: conceptualizing about how to deploy knowledge to create inventive solutions for real-life problems.
- Design problems allow engineering students to use their higher order cognitive skills and demonstrate their personality in their solutions.
- Engineering designers experience decision making, and quality control.

Description of the Engineering Design Problem

- A design problem comprises a set of system requirements and applicational constraints.

- Unlike analytical problems where solutions are unique and uniform, design problems can have many feasible solutions that satisfy the design requirements or specifications.

System Requirements

- The customer's "need, want, preference, value, purpose, objectives, and/or goals" motivate design thinkers to create solutions.
- The starting point is a list of design requirements or a system's description that the designer should observe when coming up with a solution.
- This list is usually prescribed by a customer, or an end user of the product designed to carry out a particular functionality.
- The designer would have to work with the customer to bridge the gap between "what is required" and "what is attainable."

System Requirements

- Engineers must relate their designs to factors that can be of relevance to the real world.
- Engineering designs bear close impact on community, corporate, and both national and international economies.
- Engineering designers must evaluate the impact(s) of their solutions on contexts like environmental effects; public health; global, cultural, and societal aspects; diversity, equity, and inclusion; welfare and safety; and economic factors.

Design Constraints

- The second step for a design thinker is to identify the engineering constraints for the underlying problem.

- Defined as "the rules, requirements, relations, conventions, and principles that define the context of designing."

Design Constraints

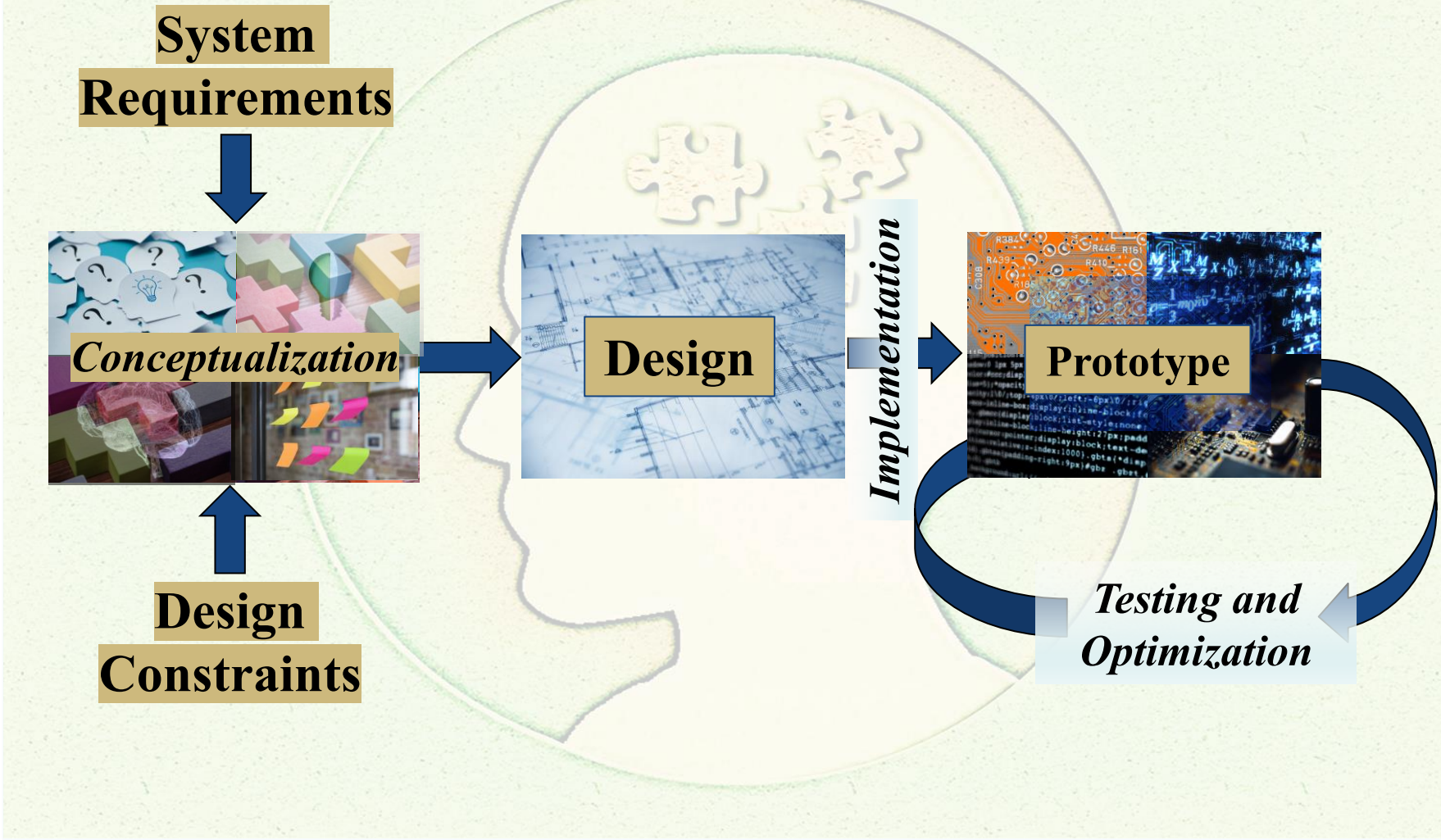
- Constraints usually comprise elements, of technical or non-technical nature, that affect the solution to the design problem, but the designer has little or no control over.

- Engineering designers need to work their way around in order to optimize their solutions in spite of those constraining factors, or bottlenecks.

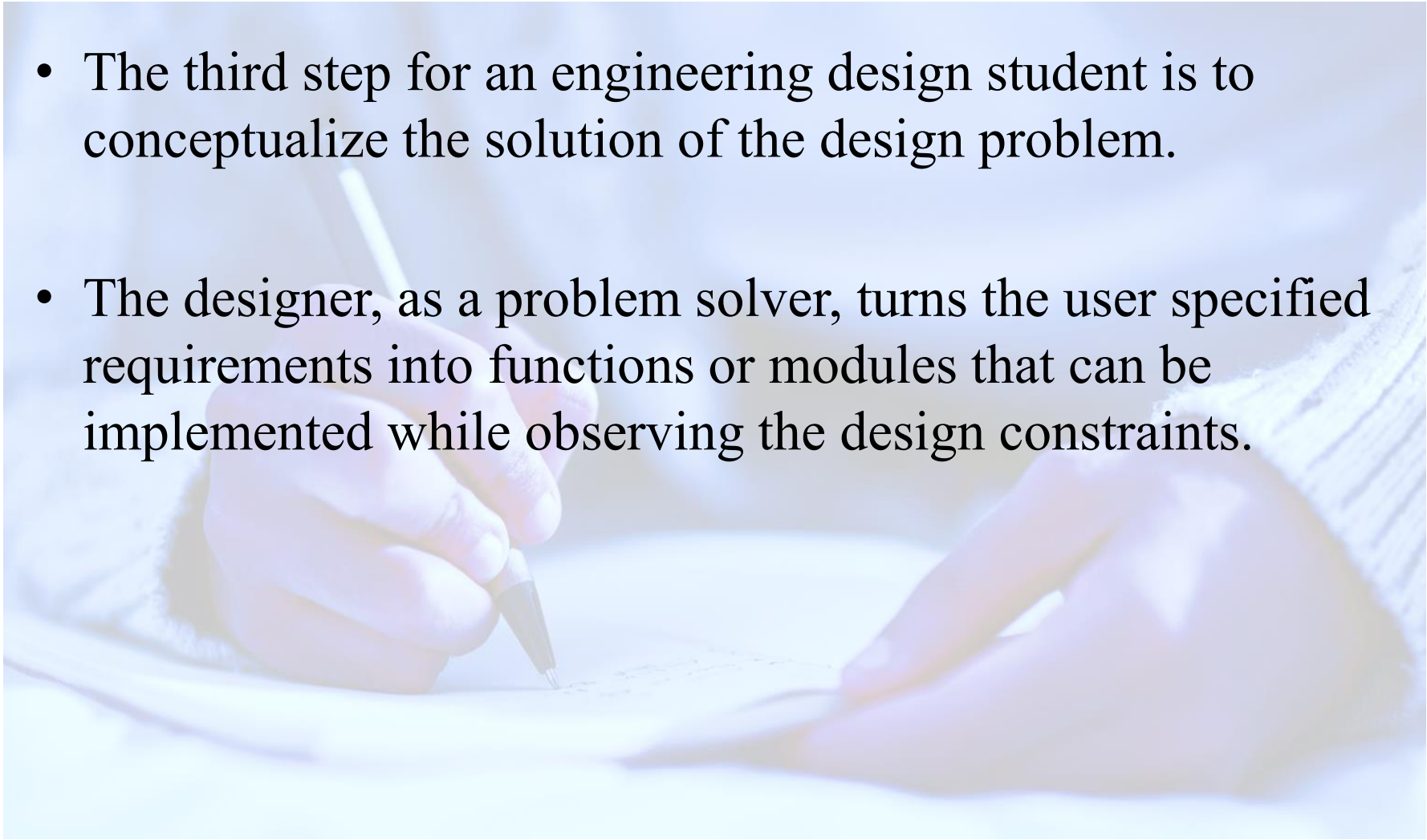
Design Constraints

- **Non-technical constraints include:**
  - Time to complete the project
  - Costs or budget
  - Manpower (the number of students working on the assignment)
- **Technical constraints are more specific to the system requirements, e.g.:**
  - Wire gauge for certain amperage
  - Health Insurance Portability and Accountability Act (HIPAA) for systems that monitor and communicate health information

Elements of the Design Problem



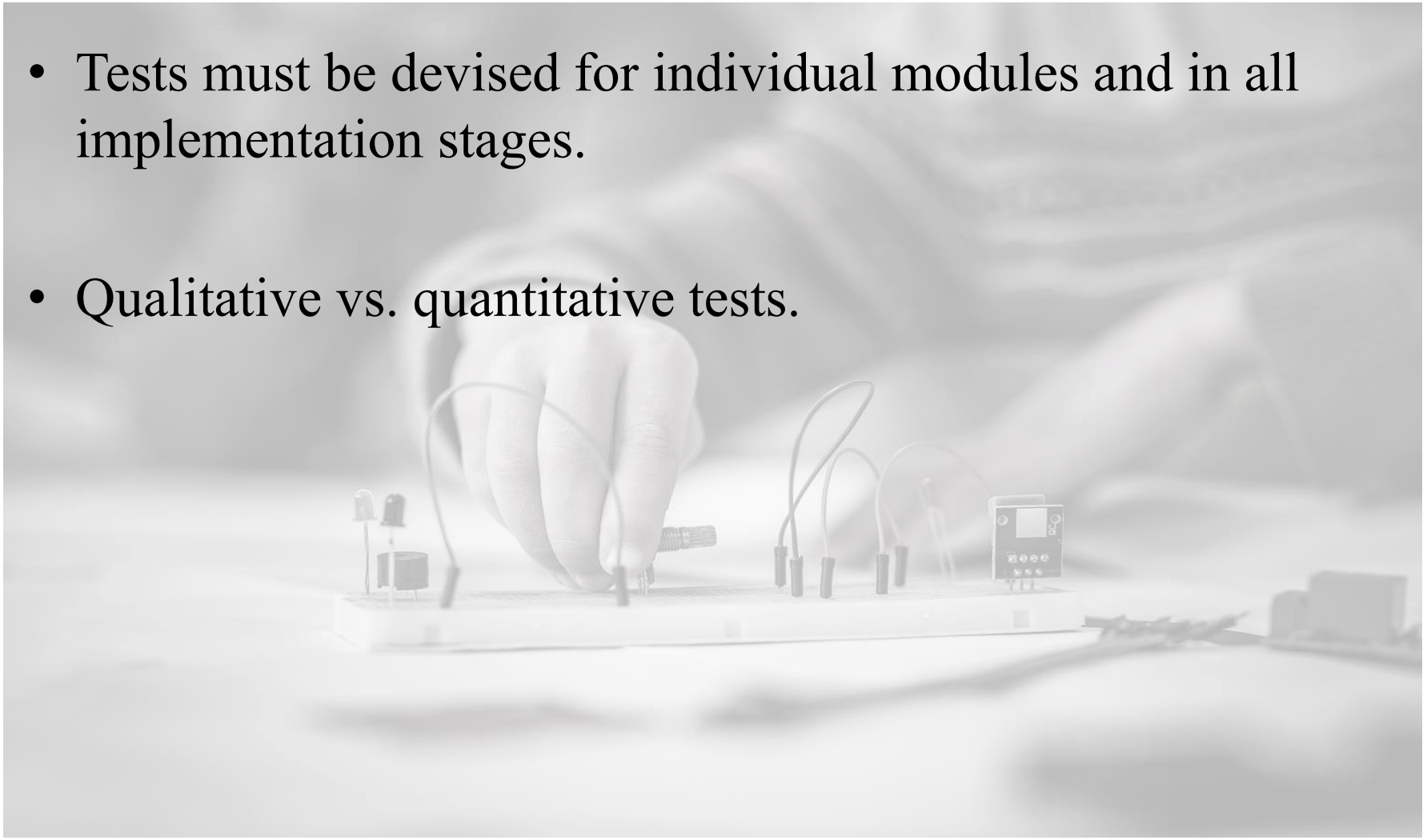
Design Conceptualization



- The third step for an engineering design student is to conceptualize the solution of the design problem.

- The designer, as a problem solver, turns the user specified requirements into functions or modules that can be implemented while observing the design constraints.

Design Testing



- Tests must be devised for individual modules and in all implementation stages.
- Qualitative vs. quantitative tests.

- Conceptual Design Document

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. Also include a high-level description of the prototype you will deliver. (~1 page)

Background

- The purpose of this section is for you to provide more details on the need for your design. Why is a better solution needed? What other solutions currently exist? What have others tried? What is unique about your design? (~2 pages)
- This section should contain **plenty of references** to other works.

System Requirements

- 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.
- State what the requirements are, and in separate paragraph, describe details of or justifications for the requirement.

Design Constraints: Standards and Impacts

- A constraint imposes a limitation the design from an external source.
- Different from design requirements, not based on customer's needs.
- Describe three constraints in addition to time, budget and manpower.

Design Constraints: Standards and Impacts

- You must consider the impact of your design in the following non-technical contexts, and describe the expected impact:
  - Environmental
  - Public Health
  - Global, Cultural and Societal
  - Diversity, Equity and Inclusion
  - Welfare and Safety
  - Economic (not budget or cost)

  Also specify if your design is irrelevant to any of these factors.

Conceptual Design

- This is the most important section and should be very detailed.
  - How much? Your design will change and evolve as the semester moves so, no not every aspect will be decided on. However, you should be able to list viable options for most components and sub-systems. This section should have enough detail that you can begin working on the prototype in some way.
  - **Include plenty of diagrams and figures!**
- You must consider **at least two different design concepts**.
  - The design concepts may be very similar, but not identical (e.g., the use of Sensor A *vs* Sensor B, or algorithm X *vs* algorithm Y)

Conceptual Design

- For each design concept, you must describe what you will design.
  - What hardware will you design? Assembling components on a PCB is not sufficient.
  - What software will you design? You must implement a non-trivial algorithm.
- After you have described each design concept, you must choose one as the best solution.
  - Present and justify your final design decisions.

Sustainability Considerations

- Sustainability is a critical consideration in modern engineering practice.
- ECE plays a central role in technologies impacting energy, resource use, and environmental responsibility.
- Senior design projects should consider long-term sustainability beyond functionality and performance.

Considerations	*Examples*
Energy Efficiency	*Use low-power microcontrollers; efficient algorithms*
Renewable Energy	*Solar panels, energy harvesting*
Electronic Waste Reduction	*Modularity, repairability, recyclability*
Material Selection	*Recycled/eco-friendly materials*
Longevity & Obsolescence	*Long-term support, updates, scalability*
Social & Economic Impact	*Affordability, accessibility, resilience*

System Test and Verification

- Your test plan is how you verify all the requirements.
- The results of your test plan should answer the questions of 'Does it work?' and 'How well does it work?'
  - 'works' or 'does not work', binary test cases are needed but are not enough.
- Specify key performance criteria that are measurable, and how you will test these criteria (specify at least one per team member, you can include more if necessary).
- What experiments will you perform to measure the criteria?

Team

- Everyone must assume sole responsibility for at least one technical aspect of the design.
- Describe the composition of your team and the division of labor.
- You will be evaluated as a group, but you will also be evaluated individually at Checkoffs.
- Roles are subject to change as the semester moves forward.
- Roles cannot be ambiguous, vague or significantly overlap with that of another team member.

Team

- Skills Learned in ECE coursework.
  - Every team member must apply some knowledge gained through their prior coursework.
  - Be specific about which courses and what knowledge will be needed.
- Skills Learned Outside of ECE coursework.
  - You will also need to learn new skills, list these for each team member.
  - How will you gain these new skills? What learning strategies will you use?

Schedule

- Draft a schedule for your project, showing what each team member will accomplish each week.

Budget

- What parts will you need, and how much will they cost?
- What will you purchase in your first order?

Minimum Standard for Project Completion

- You might not achieve all of what you propose. List the 'worst-case' scenario for minimal success.
- The minimum standard for a passing grade , not a good grade.

Final Demonstration

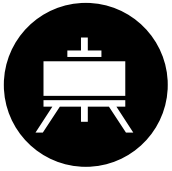
- At the end of the term, you will demonstrate your prototype to the class, describe what you will demonstrate.
- Different from the minimum standard; incorporates all of the features that should be working for a good grade.

Grading Your Conceptual Design Document

THE CONCEPTUAL DESIGN DOCUMENTS WILL BE CAREFULLY REVIEWED AND GRADED.

GIVE THIS DOCUMENT A LOT OF ATTENTION!

IT COUNTS AS 10% OF YOUR TOTAL GRADE FOR THE SENIOR DESIGN PROJECT.



A TEMPLATE AND A GRADING RUBRIC POSTED ON CANVAS.

EXAMPLE REPORTS ARE POSTED ONLINE.

NOTE, NONE OF THESE REPORTS ARE PERFECT, BUT THEY CONTAIN GOOD EXAMPLES FOR SOME OF THE REQUIRED SECTIONS.

Next Milestones

Conceptual design is due on Friday 9/26 before midnight.

We will provide resources that focuses on building up practical skills needed to complete your project (TBD)

- Hardware design (e.g. PCBs).
- Rapid prototyping (e.g. 3D printing).

Your first progress checkoff will take place on Monday 10/6. You must be ready to place your first parts order next week.

- Use your budget wisely, you should not order everything you **think** you might need, order enough to keep the project moving forward and enough to keep everyone busy.

Domain Advisor

- You are encouraged to contact a domain expert based on the technical problem that you face during working on your project.
- Think of the domain expert as a ‘consultant’, there to give you advice that you may or may not use. You may be instructed to consult multiple domain experts.
- You can keep your domain expert in the loop and take advantage of them. However, they will not be involved in the grading process. Their role is to provide you guidance.