A14-A23: Engineering Design Project

This project includes (8) milestones.

Purpose of this project

Engineers impact the world by designing objects and systems (e.g., roads) people use regularly. Design is so embedded into daily life that often people do not realize the importance of engineering unless there is a problem (e.g., water shortage). This brings great responsibility to the work of engineers.

To a novice eye, the design process may seem simple: define the problem, generate solutions, and build & test prototypes. Yet, cognizant engineers see problems differently as they:

- recognize **complexity** even in problems that seem simple
- strive to **balance trade-offs** between technical, economical, and social (human and environmental) aspects of a problem
- persistently gather information and data **as evidence** to guide their decisions and convince their client/target audience

Navigating engineering design projects also necessitates skills in:

- **project management** of time, budget, human resources.
- technical **communication** of design ideas, decisions, and evidence in visual, oral, and written forms.

This final design project provides you with an opportunity to practice design, while applying your prior knowledge and developing new knowledge, that you will be expected to demonstrate as an engineer.

Project Description

Please refer to the “Design Project Description” document for your section.

Relevant Course Resources:

Assignment Resources	• The “Design Project Description” introduces the design need and includes information on the expectations of the client • The “Design Project Template” outlines sections of your project report and specific expectations • Check the project folder in Brightspace for any additional project documents unique to your section
Video Modules	• Given that this is a culminating project, all prior video modules associated with the course are relevant to this project.

Organizing Your Work
Pay attention to how you format and organize your work in your technical report, Excel spreadsheet, and any supplemental documents. Below are some general instructions:

Technical report:

- Follow the detailed instructions given in your technical report template.

Submission Instructions:

- Complete all design milestones **as a team.** One member of your team must submit your work on Brightspace, but all team members should review the submission
- Technical Report:
  Name your Word file: **A##_DesignReport_teamnum.docx**
  Note: With each milestone you will *only complete specific parts* of your project report template, later parts will be completed later. You will work towards building a complete project report at the end of the semester. As you receive feedback, make updates and corrections to your earlier milestones. While the milestones will be graded on specific sections, your final report will be graded as a whole.

- Submit your work through the designated **Brightspace Assignment Dropbox at** https://purdue.brightspace.com/

Assignment A14:	**Problem Scoping**
Goal	Experienced engineers do not prematurely start generating solutions. Initially, they spend a significant amount of time scoping the problem and understanding the need. Problem scoping is a critical activity that occurs early in a design process but then is iterated (re-visited) throughout the design process. When problem scoping, engineers: • explore the problem context, • ask questions to deeply understand the needs of the users, • clarify the design requirements (criteria & constraints), and • build new technical knowledge/consult others when necessary. To accomplish these, engineers engage with stakeholders and experts (meet with client, observe or interview users, talk to colleagues, etc.). **Technical Report:** With each milestone you will only complete specific parts of your project report template, later parts will be left as is. Your milestone will be graded on the specific sections indicated below: • Cover page • Table of contents (right-click to Update Field automatically) • Team member roles (II) • Problem scoping (III) • References (IX) **Excel Spreadsheet**: Not required. If included as supplement, the spreadsheet should be mentioned in the report with an in-text citation and be well organized and easy to understand. Use cell referencing and Excel functions for ease of calculating.

Check Your Work with the Learning Objectives:

Learning Objectives
EB02 - Identify assumptions made in cases when there are barriers to accessing information.
IL01 - Ask questions to determine what new information is needed to scope and solve a problem.
IL02 – Gather information from reliable sources.
IL04 - Include citations within the text (in text citations) that show how the references at the end of the text are used as evidence to support decisions
IL05 – Format reference list of used sources that is traceable to original sources (APA or MLA are recommended)
PC01 - Use professional communication (written, visual, and oral), free of grammatical or spelling mistakes and in a formal tone, appropriate for engineering school and workplace.
PC05 - Fully address all parts of assignment by following instructions and completing all work.
PS01 - Explain the problem based on synthesis of client, user, and other stakeholder needs
PS02 - Justify why problem is important to solve by making reference to relevant global, societal, economic, or environmental issues.

PS03 - Explain key specifications (in terms of criteria and constraints) that address what the client wants and what the user needs.
PS04 - Identify potentially competing or conflicting needs.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A15:	**Idea Generation**
Goal	One of the key characteristics of informed designers is rich idea generation. The idea generation process requires an open-minded, non-judgmental process whereby, even the ideas that may initially look unfeasible can be explored to facilitate innovative design solutions. The purpose of sketching and prototyping is not simply communicating your design ideas but more importantly to test, experiment, verify, or validate these ideas. **Technical Report:** In the design project report template complete the following sections of the report: • Make improvements to the previous sections • Team member roles (II) • Idea generation and thought experiments (IV) • Iteration #1 (V) **Excel Spreadsheet**: Not required. If included as supplement, the spreadsheet should be mentioned in the report with an in-text citation and be well organized and easy to understand. Use cell referencing and Excel functions for ease of calculating.

Check Your Work with the Learning Objectives:

Learning Objectives
EB06 - Clearly articulate reasons for answers when making decisions or evaluating alternative solutions.
IF01 - Generate a wide range of solutions including ideas not readily obvious or combinations of ideas in new ways.
IF02 - Explicitly use and document two or more ideation strategies (biomimicry, brainstorming, exploration of prior art, etc.) to generate ideas
IL04 – Include citations within the text (in-text citations) that show how the references at the end of the text are used as evidence to support decisions.
IL05 – Format reference list of used sources that is traceable to original sources (APA or MLA are recommended)
PA02 - Identify limitations in the approach used.
PA03 - Identify potential behaviors to improve approach in future problem solving/design projects.
PC04 - Professionally present all visuals representations (figures, images, sketches or prototypes) to clearly convey meaning by labeling key components to show their form and function.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A16:	**Prototyping, Testing, & WDM**

Goal

Prototyping is essential in engineering design as it allows design ideas to be communicated and tested in order to verify/validate design functionality and usability. You will prototype your ideas, test them to collect data on their performance, and use a weighted decision matrix to compare how well each of your design ideas meet design requirements (criteria and constrains).

Technical Report: In the design project report template, complete the following sections of the report:

- Make improvements to the previous sections (document in Section VII Iteration #2)
- Team roles (II)
- Prototyping, Testing, & WDM [VI]

Excel Spreadsheet: Required.

- An Excel template for your weighted decision matrix is provided. Make sure to watch the video module on creating WDM. Also, use cell referencing and Excel functions for ease of calculating.
- The spreadsheet should be mentioned in the report with an in-text citation and be well organized and easy to understand.

Check Your Work with the Learning Objectives:
Technical Report

Learning Objectives
EB01 - Test prototypes and analyze results to inform comparison of alternative solutions.
EB03 - Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.
EB04 - Justify chosen metrics and the corresponding assigned weights to evaluate potential solutions, based on stakeholder needs.
IF03 - Generate testable prototypes for a set of potential solutions.
PC03 - Present all visuals with captions (e.g., figure number, table number, and brief description)
PC04 - Professionally present all visuals representations (figures, images, sketches or prototypes) to clearly convey meaning by labeling key components to show their form and function.
SQ02 - Justify design solution based on how well it meets criteria and constraints.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Excel Spreadsheet with WDM

Learning Objectives
DV01 - Efficient use of engineering tools for basic statistics. Use of automated solutions, such as cell referencing and built in functions.
DV04 - Prepare a table for technical presentation with proper formatting
PC05 - Fully address all parts of assignment by following instructions and completing all work.
SQ01 - Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions

Assignment A17:	**Preliminary Presentation**
Goal	Design review sessions are common in engineering. During these sessions engineers communicate their ideas and evidence to receive feedback from their clients and colleagues. The presentations for design review sessions may take many forms; however, the content of your presentation must include: • Introduction of the team (TW02) • Problem statement (PS01, PS02, PS03) • Brief review of prior art and their limitations • Summary of alternative solutions considered (IF01) • As illustration of the prototype testing protocol/process (IF03) • Details of the selected final solution (PC04) • Data supporting the selection of the final solution (how well it meets design criteria and constraints) (DV04/05, EB03, SQ01. SQ02) • Limitations of the final solution and how these could to be addressed (SQ03) • References (and in-text citations) (IL04, IL05) **Format Requirements:** Refer to specific format requirements and directions from your instructor.

Check Your Work with the Learning Objectives:

Learning Objectives
DV04 - Prepare a table for technical presentation with proper formatting
DV05 - Prepare a chart for technical presentation with proper formatting, including title, axes labels, appropriately scaled axes, units and appropriate markers
EB03 - Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.
IF01 - Generate a wide range of solutions including ideas not readily obvious or combinations of ideas in new ways.
IF03 - Generate testable prototypes for a set of potential solutions.
IL04 - Include citations within the text (in-text citations) that show how the references at the end of the text are used as evidence to support decisions.
IL05 - Format reference list of used sources that is traceable to original sources (APA is recommended)
PC04 - Professionally present all visuals representations (figures, images, sketches or prototypes) to clearly convey meaning by labeling key components to show their form and function.
PS01 - Explain the problem based on synthesis of client, user, and other stakeholder needs
PS02 - Justify why problem is important to solve by making reference to relevant global, societal, economic, or environmental issues.
PS03 - Explain key specifications (in terms of criteria and constraints) that address what the client wants and what the user needs.
SQ03 - To justify qualities of a solution and recognize any limitations, explain the trade-offs made to arrive at a final solution.
SQ01 - Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions
SQ02 - Justify design solution based on how well it meets criteria and constraints.
SQ03 - To justify qualities of a solution and recognize any limitations, explain the trade-offs made to arrive at a final solution.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A18:	**Peer Design Review**
Goal	In all forms of engineering, from software development to product and manufacturing engineering, design reviews are a project management tool to conduct a thorough evaluation of a proposed design. The purpose is to evaluate how well the design meets the criteria and constraints of the client. Finding shortcomings or errors in the design phase is much less expensive to fix than finding them during testing or manufacture. Your team will be assessed on how well you review the design of another team. • Participation of all team members (TW02) • Identification of strengths in the design approach (PA01) • Identification of limits of design approach (PA02) • Ask questions to determine clarify uncertainties in design approach (IL01) • Identification of potential behaviors to improve approach in design project. (PA03) • Provide complete, thoughtful comments, referring back to data when applicable, in each quadrant (EB06) • Use of professional communication (PC01) **Format Requirements:** Refer to specific format requirements and directions from your instructor.

Learning Objectives
PA01 – Identify strengths in problem solving/design approach.
PA02 – Identify limitations in the approach used.
IL01 – Ask questions to determine what new information is needed to scope and solve a problem.
PA03 – Identify potential behaviors to improve approach in future problem solving/design projects.
EB06 – Clearly articulate reasons for answers when making decisions or evaluating alternative solutions.
PC01 – Use professional communication (written, visual, and oral), free of grammatical or spelling mistakes and in formal tone, appropriate for engineering school and workplace.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A19:	**Iteration #2**
Goal	Iteration is critical in engineering design. To a novice, iteration may seem like a waste of time. However, design involves solving ill-defined problems while managing competing design requirements. Hence, iteration helps to better understand a problem and make improvement before it is too late and too expensive to do so. **Technical Report:** In the design project report template complete the following sections of the report: • Make improvements to the previous sections • Team roles (II) • Iteration #2 (VII) **Excel Spreadsheet**: Not required, unless feedback on WDM suggested revisions of the WDM. If included as supplement, the spreadsheet should be mentioned in the report with an in-text citation and be well organized and easy to understand.

Check Your Work with the Learning Objectives:

Learning Objectives
PA02 - Identify limitations in the approach used.
PA03 - Identify potential behaviors to improve approach in future problem solving/design projects.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Excel Spreadsheet with WDM (optional)

Learning Objectives
DV01 - Efficient use of engineering tools for basic statistics. Use of automated solutions, such as cell referencing and built in functions.
DV04 - Prepare a table for technical presentation with proper formatting
SQ01 - Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions

Assignment A20:	**Final Report**

Goal

In previous assignments you have been building the early section of your project report. This is your chance to review all previous sections using the feedback you received and make improvements as you finalize your solution.

Technical Report: Complete all sections of the project report:

- Cover page
- Executive summary (I)
- Table of contents (right-click to Update Field automatically)
- Team member roles (II)
- Problem scoping (III)
- Idea generation and thought experiments (IV)
- Iteration #1 (V)
- Prototyping, Testing, & WDM (VI)
- Iteration 2 (VII)
- Overview of Final Design (VIII)
- References (IX)
- Appendices (X)

Excel Spreadsheet: Not required.
If included as supplement, the spreadsheet should be mentioned in the report with an in-text citation and be well organized and easy to understand. Use cell referencing and Excel functions for ease of calculating.

Check Your Work with the Learning Objectives:
Technical Report

Learning Objectives
DV01 - Efficient use of engineering tools for basic statistics. Use of automated solutions, such as cell referencing and built in functions.
DV02 - Select appropriate graphical representation of dataset based on data characteristics such as numerical (discrete or continuous) or categorical (ordinal or nominal)
DV04 - Prepare a table for technical presentation with proper formatting
DV05 - Prepare a chart for technical presentation with proper formatting, including title, axes labels, appropriately scaled axes, units and appropriate markers
EB01 - Test prototypes and analyze results to inform comparison of alternative solutions.
EB02 - Identify assumptions made in cases when there are barriers to accessing information.
EB03 - Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.
EB04 - Justify chosen metrics and the corresponding assigned weights to evaluate potential solutions, based on stakeholder needs.
EB05- Present findings from iterative testing or optimization efforts used to further improve aspect or performance of a solution
EB06 - Clearly articulate reasons for answers when making decisions or evaluating alternative solutions.
EE02- Predict/identify the potential ethical dilemmas and consequences that result from implementing solutions.
IF01 - Generate a wide range of solutions including ideas not readily obvious or combinations of ideas in new ways.

IF02 - Explicitly use and document two or more ideation strategies (biomimicry, brainstorming, exploration of prior art, etc.) to generate ideas
IF03 - Generate testable prototypes for a set of potential solutions.
IL01 - Ask questions to determine what new information is needed to scope and solve a problem.
IL04 - Include citations within the text (in-text citations) that show how the references at the end of the text are used as evidence to support decisions.
IL05 - Format reference list of used sources that is traceable to original sources (APA is recommended)
PA01 - Identify strengths in problem solving/design approach.
PA02 - Identify limitations in the approach used.
PA03 - Identify potential behaviors to improve approach in future problem solving/design projects.
PC02- Use professional communication (written, visual, and oral), free of grammatical or spelling mistakes and in a formal tone, appropriate for engineering school and workplace.
PC03 - Present all visuals with captions (e.g., figure number, table number, and brief description)
PC04 - Professionally present all visuals representations (figures, images, sketches or prototypes) to clearly convey meaning by labeling key components to show their form and function.
PC05 - Fully address all parts of assignment by following instructions and completing all work.
PS01 - Explain the problem based on synthesis of client, user, and other stakeholder needs
PS02 - Justify why problem is important to solve by making reference to relevant global, societal, economic, or environmental issues.
PS03 - Explain key specifications (in terms of criteria and constraints) that address what the client wants and what the user needs.
PS04 - Identify potentially competing or conflicting needs.
SQ01 - Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions
SQ02 - Justify design solution based on how well it meets criteria and constraints.
SQ03- To justify qualities of a solution and recognize any limitations, explain the trade-offs made to arrive at a final solution.
SQ04 - Present a succinct and clear value proposition that highlights novel aspects of the solution, including key benefits.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A21:	**Final Presentation**

Goal

This is the final milestone of the design project. Throughout the project, you shared your ideas, gathered evidence, received feedback, and made many iterations. This is your opportunity to illustrate that you,

- recognize **complexity** even in problems that seem simple
- strive to **balance trade-offs** between technical, economical, and social (human and environmental) aspects of a problem
- persistently gather information and data **as evidence** to guide your decisions and convince their client/target audience
- developed critical skills in **project management** of time, budget, human resources
- became proficient in technical **communication** of design ideas, decisions, and evidence in visual, oral, and written forms.

The format of final presentation may take many forms; however, the content of your presentation shall include:

- Introduction of the team (TW02)
- Problem statement (PS01, PS02, PS03)
- Brief review of prior art and their limitations
- Summary of alternative solutions considered (IF01)
- An illustration of the prototype testing protocol/process (IF03)
- Details of the selected final solution (PC04)
- Data supporting the selection of the final solution (how well it meets design criteria and constraints) (DV04/05, EB03, SQ01. SQ02)
- Limitations of the final solution and how these could to be addressed (SQ03)
- References (and in-text citations) (IL04, IL05)

Format Requirements:
Refer to specific format requirements and directions from your instructor.

Check Your Work with the Learning Objectives:

Learning Objectives
DV04 - Prepare a table for technical presentation with proper formatting
DV05 - Prepare a chart for technical presentation with proper formatting, including title, axes labels, appropriately scaled axes, units and appropriate markers
EB03 - Clearly articulate reasons for answers with explicit reference to data to justify decisions or to evaluate alternative solutions.
IF01 - Generate a wide range of solutions including ideas not readily obvious or combinations of ideas in new ways.
IF03 - Generate testable prototypes for a set of potential solutions.
IL04 - Include citations within the text (in-text citations) that show how the references at the end of the text are used as evidence to support decisions.
IL05 - Format reference list of used sources that is traceable to original sources (APA is recommended)
PC04 - Professionally present all visuals representations (figures, images, sketches or prototypes) to clearly convey meaning by labeling key components to show their form and function.
PS01 - Explain the problem based on synthesis of client, user, and other stakeholder needs

PS02 - Justify why problem is important to solve by making reference to relevant global, societal, economic, or environmental issues.
PS03 - Explain key specifications (in terms of criteria and constraints) that address what the client wants and what the user needs.
SQ03 - To justify qualities of a solution and recognize any limitations, explain the trade-offs made to arrive at a final solution.
SQ01 - Use accurate, scientific, mathematical, and/or technical concepts, units, and/or data in solutions
SQ02 - Justify design solution based on how well it meets criteria and constraints.
TW02 - Document all contributions to the team performance with evidence that these contributions are significant.

Assignment A23:	**CATME Peer and Team Evaluation #3**
Goal	It is vital for engineers to learn how to give and receive constructive feedback. You will be required to use the CATME peer and team evaluation tool to explain the contributions of each of your team mates and give constructive criticism and/or praise for their contributions. **CATME Evaluation:** You will submit this online, the links are provided in this assignment folder in Brightspace.