THOMPSON RIVERS UNIVERSITY

Department of Engineering
Faculty of Science

Engineering Design I - ENGR 1100

Term Project

Fall 2022

Objective: The objective of this project is to design and build a Rube Goldberg Machine.

Project Description: According to the Merriam-Webster Online Dictionary (n.d.), the Rube Goldberg concept is defined as "accomplishing by complex means what seemingly could be done simply." [1] This is how Reuben Lucius Goldberg, a Pulitzer Prize-winning artist, portrayed machines and gadgets as excessive for well over 50 years. In addition, he was sometimes skeptical about the technology upon which these devices were based. His cartoons combined simple machines and common household items to create complex and wacky contraptions that accomplished trivial tasks. While most machines work to make difficult tasks simple, his designs made simple tasks complex. For instance, he designed a simplified pencil sharpener, a safety device for walking on icy pavements; he dealt with problems like putting a stamp on an envelope, screwing in a light bulb, or making a cup of coffee in 20 or more steps. [2] An example of one of his designs is illustrated in Fig. 1.

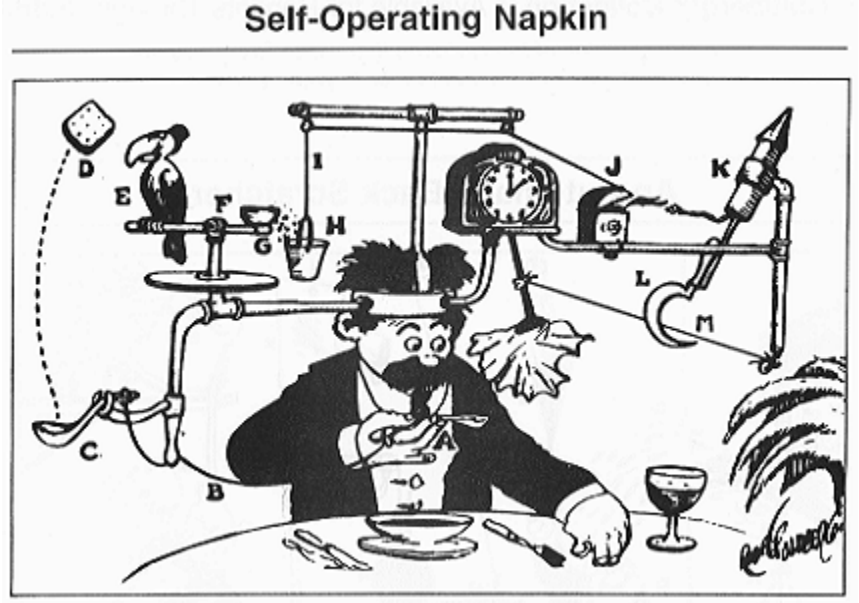


Fig. 1: Rube Goldberg Machine- Professor Butts & the Self-Operating Napkin [3]

The purpose of this project will be to design and build a Rube Goldberg Machine to complete a simple but useful task. As a class, we will brainstorm possible ideas for this task (called the Primary Task), and come to a decision about what this task will be.

Project Groups: This project will be completed in groups of 4-5 students. The instructor will randomly create groups for all students by Monday, September 19th, 2022. Groups will be posted on Moodle.

Project Constraints:

1. Every Rube Goldberg machine has numerous steps. For instance, the machine depicted in Figure 1 has 13 steps (A to M). For this project, a minimum of 10 steps are required.
2. Items that are easily found, rather than purchased, should be used as much as possible. This includes household or office items and re-used items.
3. The value of purchased items should not exceed $50.00. Each student is expected to contribute equally.
4. Minimum human intervention during machine operation is encouraged and will result in a higher grade.
5. Non-simplistic mechanical or electrical components/devices can be used to accomplish a maximum of five of the tasks.*
6. Any food-related products should be edible.
7. Live animals should be excluded from all designs.
8. The machine's dimensions should not exceed 1.5 m long by 1 m wide by 2.5 m tall.
9. The machine should be transportable.
10. Upon transport, it should be possible to assemble the machine in 15 minutes or less and disassemble the machine in 5 minutes or less.
11. The machine should be free-standing on the ground or a table.
12. The run time of the machine should be less than 5 minutes.

* Non-simplistic mechanical or electrical components use power from an engine or electricity, or incorporate electrical circuits. Simple machines such as pulleys and levers do not fall into this category.

In addition to the above, the machine itself should have a creative or artistic theme. Students are expected to use the knowledge imparted to them during classes and labs to develop their Rube Goldberg machine. Designs should consider the economic, environmental, societal, and safety aspects. The marking scheme for the final project is discussed at the end of this document.

Assessment: The term project is worth 35% of the final grade for the course. As we work through learning the engineering design process, the course instructor will complete four progress checks throughout the term, each worth 2.5% of the final term project grade for a total of 10%. The remaining 80% of the term project grade will be placed on the final assessment of the completed project. The progress checks, final project report and presentation, and marking scheme, are provided below.

Progress check material will be shown to the instructor during a group meeting with the instructor during one of the lecture periods during the week following the due date. Students may present the material during the meetings either as hard copies (printed) or may bring a laptop to present it. Marking of progress checks will be completed during the meeting. Progress check will be marked based on level of completeness. The rubric for the progress checks is posted on Moodle.

Progress Check #1: Group roles, group rules and scheduling
Weighting: 2.5% of project mark
Due: Monday, October 3rd, 2022 (before class)

- Provide a description of the roles and responsibilities for each group member. Examples of group work roles are provided on Moodle under the Term Project heading.

- Create a Group Contract containing group rules. Discuss how you will communicate with each other. Also ensure that the consequences for breaking the rules are clear. Guidelines for creating a group contract are provided on Moodle under the Term Project heading.
- Provide a schedule of approximately when meetings will take place and how the project schedule will be divided among tasks to meet the various deadlines. This should be submitted as a Gantt chart, which can be updated for the final deliverable.
- Teamwork: Cumulatively, from each deliverable, this will form the Teamwork section of the final report. Provide details on each of the meetings (time, who was present, agenda, minutes, and a record of team rule penalties, as described in the Teamwork section of the final report template).
- Group Peer Review Form: Optional. Please complete and email this form to the instructor if any of your teammates have not met expectations for fulfilling their role.

Progress Check #2: Problem Identification & Problem Statement Generation (Total: 20 marks)
Weighting: 2.5% of project mark
Due: Mid-October (Check Moodle)

- Complete Sections 2 and 3 of the final report: Introduction and Design Problem. Students must follow the Final Report Template provided on Moodle. This includes:
    - A draft of the introduction. Introduce the subject, scope and purpose of the report. There needs to be background research. Ensure that all background research conducted is referenced properly according to IEEE style, and a bibliography is provided. (Note that the introduction will be edited prior to completion of the final report to include the general conclusions at the end).
    - A well-thought-out problem definition.
    - Identification of the design requirements, including objectives (with an objective tree) and constraints.
- Teamwork: Provide details on each of the meetings (time, who was present agenda, minutes, and a record of team rule penalties, as described in the Teamwork section of the final report template) since the last deliverable.
- Group Peer Review Form: Optional. Please complete and email this form to the instructor if any of your teammates have not met expectations for fulfilling their role.

Progress Check #3: Conceptual Design
Weighting: 2.5% of project mark
Due: Early November (Check Moodle)

- Complete all of Section 4 of the final report: Solution Development, except the final section entitled “Components and Features.”
- Generate a minimum of three different alternate concepts as potential solutions. There should not be one that is clearly superior to the others. Sketches, drawings and/or diagrams should be provided showing the primary components of each alternative. These can be supplemented a written description of the alternative.
- Describe the advantages and disadvantages of each solution. Structure the description of each design alternative the same way, with information given in the same order using the same formatting in order to make it easier for the reader to understand the comparison.
- The most feasible solution should be selected. Explain why it is better than other solutions. Use a table for comparison purposes.
- Create a function tree for the final solution. Each step should be one arm of the tree.
- Teamwork: Provide details on each of the meetings (time, who was present agenda, minutes, and a record of team rule penalties, as described in the Teamwork section of the final report template) since the last deliverable.
- Group Peer Review Form: Optional. Please complete and email this form to the instructor if

any of your teammates have not met expectations for fulfilling their role.

Progress Check #4: Product Design Drawings
Weighting: 2.5% of project mark
Due: Monday, November 21st, 2022 (before class)

- Complete the final section of Section 4 in the final report: Components and Features. Describe the physical process and energy transformations that are powering the motion in each step of the machine and refer to your drawings as needed.
- Using SolidWorks, or the program of your choice, complete DRAFTS of labelled drawings showing 3 consecutive steps (tasks) of your choice, out of the 10 steps, as designed, should be drafted. If your team is having issues drawing certain aspects of one of your chosen steps, then provide notes that describe it verbally. This is about communicating your design.
- Criteria for drawings:
    - Each drawing must be labelled and numbered in the sequence that it occurs in the Rube Goldberg Machine.
    - There should be a sufficient number of views and dimensions to be able to replicate each part with the correct geometry.
    - Limitations in student's knowledge of SolidWorks will be considered during evaluation of this component of the project. A document that summarizes the obstacles faced for each of the drawings due to limited knowledge of the program, and the workarounds that were done to create the most realistic drawing may be provided with this deliverable to account for this.
- Teamwork: Provide details on each of the meetings since the last deliverable (time, who was present, agenda, minutes, and a record of team rule penalties, as described in the Teamwork section of the final report template).
- Group Peer Review Form: Optional. Please complete and email this form to the instructor if any of your teammates have not met expectations for fulfilling their role.

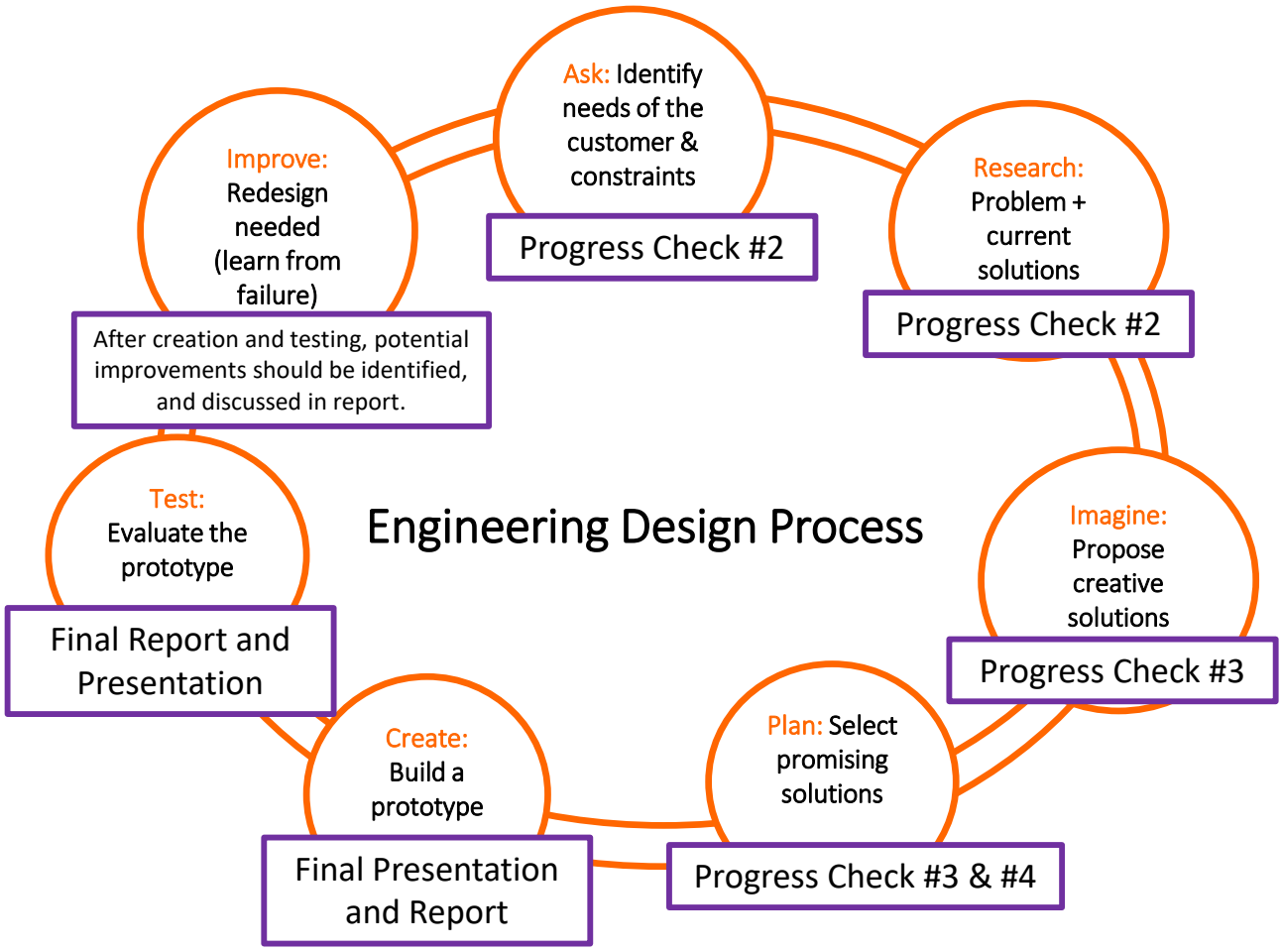
Final Report and Presentation: Product Development, Testing, Implementation and Reporting
Weighting: 90% of project mark
Presentations Due: Week of November 27th, 2022
Report Due: Monday, December 5th, 2022

- A fully functional prototype must be provided during the last week of classes for testing. Prior to bringing it to the lab for testing, it should be assembled and tested elsewhere to ensure it is working as intended.
- A technical report must be submitted by the project due date. Some of this work will have been completed during Progress Checks #1-#4. The technical report and the prototype itself will be graded as follows:
    - Executive Summary. A brief summary of the report. Written last. See the Final Report Template for more guidance. (10 marks)
    - Introduction. (10 marks)
    - Problem definition. (3 marks)
    - Design Selection. (12 marks)
        - SolidWorks Drawings (20 marks)
    - Prototyping and Development Testing. The marking scheme for this section is broken down into:
        - The detailed final design meets all functional requirements, and all constraints are satisfied. This is demonstrated during an in-class demonstration of the final product. Prior to running your machine, your group will have 5 minutes to explain the project and your machine. This

explanation should include the objective, the structure and the technologies used in each step, one or more interesting challenges, a comprehensive evaluation, and meaningful conclusions. Each group member should have a chance to participate. (30 marks)
        - Project creativity and aesthetics (10 marks)
        - Project complexity. Increased complexity and variety of steps results in higher marks here. (10 marks)
        - Initial testing (methods, successes, failures, and improvements) are discussed in the report. (15 marks)
        - A video or videos of initial testing and improvements are handed in on Moodle (10 marks). This does not have to be professionally edited. It is simply to provide a visual aid for understanding your iterative design process.
        - Environmental, societal, safety and economic considerations are adequately researched and discussed in the report. (20 marks)
        - Limitations of the design and end-product are discussed (5 marks)
    - Teamwork. Provide details on each of the meetings (time, who was present agenda, minutes, and a record of team rule penalties, as described in the Teamwork section of the Final Report Template) throughout the project. This will involve combining the teamwork portion from the first 4 progress checks and then adding the teamwork items since the last deliverable. Some of this can be placed in an appendix if this section gets too long. (10 marks)
    - Project Management. Provide a Gantt Chart showing how the work progressed. This is a modified version of the original Gantt chart provided during deliverable #1. Also reflect on your project management successes and failures as a team and how you can improve next time. (10 marks)
    - Conclusions. A summary of what you achieved. See the Final Report Template for more guidance. (5 marks)
    - Report Format: The report should follow the Final Report Template and all background research or borrowed content should be referenced using IEEE style. The length of the report and each section should reflect the complexity of the topic, thoroughness of the research, and effort of the design. Standard formal English should be used. (5 marks)
    - Appendix. Place the items from Progress Check #1 in the Appendix, as well as any other relevant information that is not in the main report.
- Group Peer Review Form, submitted by each student on Moodle (15 marks)

Total Marks for Final Report and Presentation: /200

A Note on Teamwork: A successful project that lacks teamwork is a failed project. Any matters that are counterproductive to the team should be brought up in a timely fashion. Please see the handout entitled “Group Work Challenges and Solutions” provided on Moodle in the Term Project section. *Note that a Group Peer Review Evaluation Form is required to be submitted on Moodle by every group member at the end of the project.* At each progress check, if one or more team members have not been fully participating in the project, students should email the instructor a filled-out Group Peer Evaluation Form. This form can be found on the course Moodle site under the section for the Term Project. For the final submission, if a student does not hand in their Group Peer Review Form, a mark of zero will be averaged with the marks given by the other students. If a student receives poor Group Peer Review Feedback during the term, they may be required to complete the remainder of the project as an individual. If a student receives an average group peer review mark of less than 11/16 on the final group peer review, the group peer review will become worth 30% of their final grade for the term project, rather than 7.5% (15/200).



Throughout: Communicate, Communicate, Communicate

References

[1] Merriam Webster, "Merriam-Webster.com dictionary," [Online]. Available: https://www.merriam-webster.com/dictionary/Rube%20Goldberg. [Accessed 12 April 2021].

[2] S. Acharya and A. Sirinterlikci, "Introducing Engineering Design through an Intelligent Rube Goldberg Implementation," *The Journal of Technology Studies,* vol. 36, pp. 63-73, 2010.

[3] Wikipedia Commons, "Wikipedia," 2021. [Online]. Available: https://en.wikipedia.org/wiki/Rube_Goldberg_machine. [Accessed 11 April 2021].