Student Engineer Portfolio
(Sept 2022- Apr 2023)

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Introduction

This document is a collection of my design experiences which demonstrate my abilities, potential, and design skills to the reader (Sept 2022- Apr 2023).

My portfolio is thoughtfully structured to provide a comprehensive overview of my engineering design activities that have shaped my skills and experiences. It includes brief descriptions of my design work, reflections and learnings accompanied by images that provide a visual representation of my work and skills.

My objective in presenting this portfolio is to provide the reader with evidence that I practice according to my position as a student engineer and that I possess the necessary skills and expertise to excel in the field. The portfolio is a living document that I intend to build upon throughout my career as I gain more design experience. It will serve as an asset that reflects my growth and development as an engineer.

About the Author

Fig-1: Author, Riya Mathur

I was born in one of the oldest cities in India, Jodhpur, which is known for its rich cultural history and multi-ethnicity. Conversely, my recent life has unfolded in the fast-paced metropolitan city of New Delhi and Toronto, where people make the most of every passing minute, passionate about achieving 'big' in their lives. This, in turn, inspired me to use my time judiciously and for the benefit of society, thus I chose the path of engineering. But apart from this, it was my non-scholastic and extracurricular activities that brought colors and added experience into my life. As a result, I grew up to be a unique blend of the best of both worlds, ambitiously or the greater good, while being rooted in the tradition and values that my upbringing in the native land taught me.

Moreover, my direct personal inspiration to be an engineer comes from understanding a difference, a difference in the social, economic, and environment in which my father with his six siblings grew up and in which I was raised. The fact that even though my father's family wasn't well off, he fought all odds to make his family's life better and thus, excelled to become a geologist. His life story and struggle inspire me to make the best of all the privileges of education and financial stability that I have grown into, which is prevalent in all my academic and professional pursuits in my life. Other than this, my dad has taught me the importance of being an independent woman in the 21st century, and when I see strong independent female engineers and entrepreneurs positively reshaping the world, it inspires me to the core and makes me want to be like them.

I have developed a deep interest in areas which require problem-solving and critical thinking skills. Additionally, I find satisfaction in seeing the tangible results of my work, such as structures, research, or programs. I also enjoy working in teams on projects and being part of a community of like-minded students. In 2022-23, I worked with the University of Toronto's Robotics Association (Computer Vision team), in which I built computer programs to help robots identify obstacles and hurdles on a path. I was also part of a research team working on Implantable Piezoelectric Energy Harvester for Pacemaker. These experiences gave me an insight into the real-world industry work and taught me invaluable skills.

As a future engineer, my core principle values are Inclusivity, Compassion, and Accountability. As a woman, I have observed and experienced instances where the perspectives and needs of women were not adequately considered in the design and development of products, systems, and infrastructure. Thus, I understand how frustrating it can be to be part of an under-represented community and this drives me to make efforts to address this issue and ensure that the perspectives and needs of all individuals are considered in the design process. Also, to come up with innovative solutions to problems, it is important for me to be emotionally connected to the issue. This is where compassion comes in, as it helps me stay motivated and engaged throughout the design process, resulting in better quality work.

Therefore, studying engineering for me is more than just a degree and job, it's the ability to empower and provide under-represented communities with all the facilities they need to develop and grow without any constraints. As an international female engineering student, I believe that I will be able to practice engineering design through a more socially- inclusive lens, in which the needs of all stakeholder communities will be considered equally to influence designs.

CIV102: Bridge Design and Construction

Opportunity: In a group of four, our task was to apply the concepts taught in CIV102 course to design and build a small-scale box girder bridge out of limited amount of matboard that would be subjected to increasing loads until failure. The project challenged our ability to design a bridge that can handle the highest loading possible and to be accurate in our estimation of the final failure load. To start the process of iterative design, an initial design (Design 0) was provided.

Skills used:

1. I, with the help of my teammate, wrote a **python code** (Fig-2) to determine the optimal dimensions of our bridge. The code took input values of our desired parameters for the bridge such as the width of the flanges, the height of its webs, etc. and the script executed a set of calculations taught in CIV102 to output values such as the moment of inertia, applied stresses the bridge experiences etc.

2. **Practical skills** like cutting, measuring, and assembling bridge components using given material (Fig-4).

3. Created multiple **engineering drawings** of the bridge (part of project submission)

4. **Motivated and supported the team** throughout the project, aiding in overcoming challenges and encouraging a more cohesive team environment.

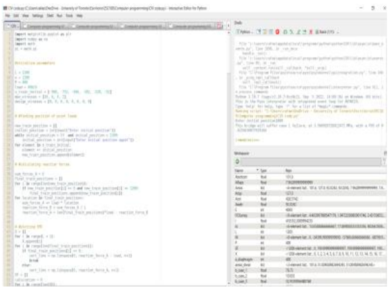

Fig-2: Python Script for dimensions optimization

Fig-3: Final bridge on the day of testing

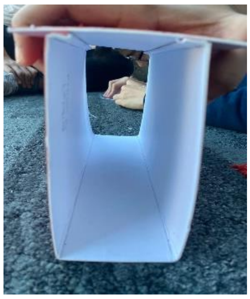

Fig-4: Building the hollow cross-section of bridge

Skills gained:

1. Learned **time management skills** by working on a large project in a small-time frame. The team prioritized tasks, and distributed work according to their strengths which ensured that every team member worked on a task that they could do best, which increased overall productivity.

2. My key learning from this project was how to **be patient during the design process** as our team kept rediverging and converging to select the strongest bridge beam type**.** I gained firsthand experience of how reiterative a design process can be, and the entire team must go through it together to complete the project successfully instead of burdening one single person with workload.

3. I learnt to perform **data analysis** and honed my mathematical skills to get an accurate estimation of the final failure load.

4. **Trusting your teammates instinct and accepting one's own mistake**. There were moments when the team benefitted by showing faith in others' ideas and vision. This can be difficult to do sometimes but I understand that one person cannot always be right.

Final Design Outcome: Our bridge passed the minimum load testing, however failed to meet the theoretical prediction of failure load calculated by the team. The bridge ultimately failed due to shear bending, which was an oversight in the design process. The team took accountability for not anticipating the correct real strength of the bridge and not designing it in a way that could respond to a range of loading conditions. Although the bridge partially failed, it was a great learning experience and an opportunity to grow as an engineering designer (Fig-3).

ESC101 Design Project

Opportunity: My praxis-I team had to develop and recommend a design concept which addressed the discomfort of wet-umbrella handling in the indoor setting of McLennan Physical Laboratories.

Skills and Tools Used:

1. Used my advanced **communication skills** to effectively collaborate with teammates, have productive brainstorming sessions, resolve conflicts among certain teammates, create a positive harmonious environment (feedback from one of my teammates), and distribute work evenly among all.

2. **Sketching** proved to be an invaluable tool for effectively communicating my ideas to my team. This was particularly important during the divergent phase, where different perspectives and approaches were being considered (Fig-6).

3. Used **biomimicry** while diverging to find a design solution that mimics how nature- like leaves and animals- dry themselves after getting wet. The fundamental concepts researched were hydrophobic surfaces and spinning motion. The idea was well appreciated by my team and our final design was ultimately based on biomimicking a mammal that can remove about 70% of the water trapped in its fur by "tuning" their spin to achieve maximal dryness with the least effort.

Fig-5: Showcasing prototypes to teaching team

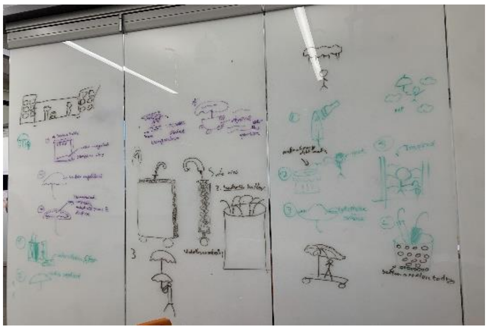

Fig-6: Sketches made during diverging phase

Skills Gained:

1. Learnt the skill of **opportunity rescope**, as demonstrated by our team's experience in designing a solution for the inconvenience of carrying wet umbrellas anywhere. Initially, we encountered challenges due to the broad scope, so we focused our design space on a single building- McLennan Physical Laboratories. By narrowing the scope, we were able to identify specific requirements and constraints, resulting in a more focused and effective solution. This experience taught me the importance of scoping opportunities carefully to ensure successful outcomes.

2. Learnt to **prototype design concepts** (Fig-5) to bring them to life and test the viability of the design, allowing me to gain a first-hand understanding of its practicality before investing significant time and resources. Prototyping also helped me to iteratively refine my ideas and compare multiple designs at once.

3. To converge, thoroughly **tested design requirements** set by team on shortlisted designs – shake dryer, spin dryer, heat dryer etc. to find the most efficient design for shedding water from umbrellas (Fig-7,8)

4. As an international student, I struggle to translate my thoughts and write them concisely in English. However, Praxis-I assignments like strand-analysis and report writing provided me with multiple opportunities to make mistakes and learn from them, helping me to **develop my writing proficiency and communicate more effectively in English.**

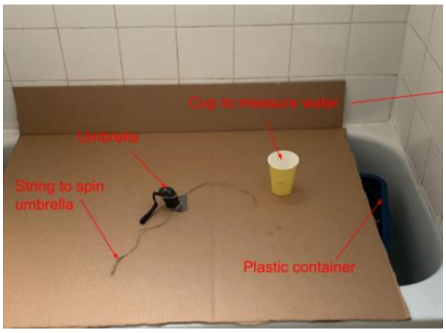

Fig- 7: Prototype testing setup for shake dryer

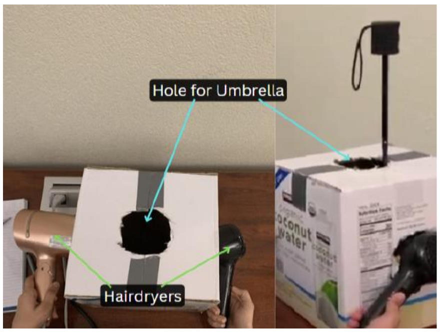

Fig- 8: Prototype testing setup for spin dryer

Final Recommended Design – Spin Dryer:

- Purpose: To shed water from an umbrella by spinning it

- Structure: A cylindrical double-layered unit with a 24 cm height consisting of four main components (Fig-9):
  1. A 30 cm diameter (chosen to fit most umbrellas) slot that inserts the wet umbrella
  2. A button on the interface to activate the machine's spin cycle
  3. Spinners on the inner sides
  4. A drain below the unit connected to a main water tank

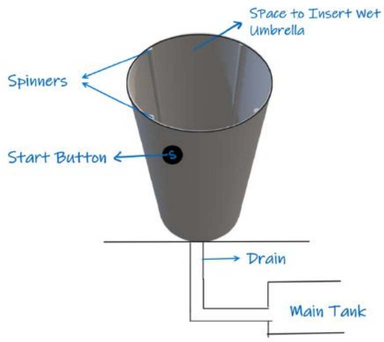

Fig-9: Labelled Diagram of Spin Dryer

- Operation: The spin dryer spins the umbrella at a frequency that creates a centrifugal force of nearly 10 times the force of gravity over a 15-second period once the button is pushed. The water that sheds through the spinning motion is drained and collected within the main tank for recycling, possibly used for the nature surrounding the building.

ESC102 Magnetic Feeder Device for Toronto Zoo

Opportunity: The Toronto Zoo Animal Husbandry Team helps animals practice their natural behaviours. They wish to encourage their white-handed gibbon, Hoot, to practice his natural foraging skills which involves swinging through 4-9 m tall trees. My praxis-II team's opportunity was to create a mechanism which helps zookeepers at Toronto Zoo to place food for the white handed gibbon at multiple elevated levels like treetops and high branches.

Skills used:

1. **Creating drawings, sketches, and physical model (of the gibbon exhibit)** with my teammates helped me throughout the engineering design process. By visually mapping out our ideas and possible designs concepts during diverging, my team and I were able to refine and improve our design until it successfully fulfilled the goal of enabling Hoot to practice his natural foraging skills.

2. **Professionally communicated with the stakeholders** online and in-person to frame an opportunity for RFP, updating them with design progress, showcasing the final design to the and asking for their feedback (Fig-10).

3. The opportunity required a lot of **secondary research** about white- handed gibbons, natural foraging techniques, existing mechanism of feeding at Toronto Zoo etc.

4. **Determination and consistency** were important skills in the rollercoaster design journey as the team met several dead-ends and had to constantly rescope, rediverge, and reconverge. Despite these challenges, the team refused to give up and remained committed to the goal, ultimately resulting in the successful design of a product that met all set requirements and constraints.

Fig-10: Picture with the Animal Husbandry Team during Showcase

Fig-11: Prototype of magnetic feeder

Fig-12: CAD model of magnetic feeder

Skills gained:

1. learned **AutoCAD** to create precise design representations and effectively visualize and modify them before building physical prototypes, which increased precision in design and cost savings for the project (Fig-12).

2. I eagerly took on the responsibility of constructing the final design prototype, which allowed me to gain valuable experience in proficiently **utilizing both hand and power tools** at University of Toronto's Myhal Fabrication Facility (Fig-12, 13).

3. Learned how to effectively communicate an entire project with complex information in a visually appealing way like poster, one-pager, and how to **distil key project information concisely** and in a digestible format.

Fig-13: Using Drill-Press machine to make parts of final design prototype

Final Design: **Magnetic Feeding Device**

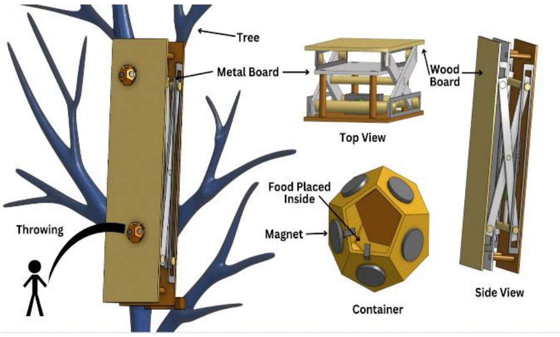

Fig-14: Final design model of magnetic feeder

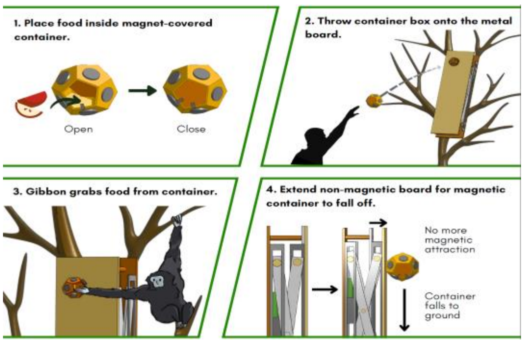

Fig-15: Step by step procedure of design use

The magnetic feeder consists of dodecahedron food containers covered with neodymium magnets on 11 faces, and a vertical metal board attached to a high tree trunk (Fig-14). The 11 magnetic faces are fixed, while the last non-magnetic face serves as a hinge "door" for Hoot to open and access the food inside. The metal board mechanism is positioned vertically in front of a tree trunk, with a wooden board that can be extended horizontally. When the wooden board is not extended and touches the metal board, the magnetic board can be thrown onto the wooden board and stick, allowing Hoot to access the food inside. As the food in the container box is emptied, the wooden board extends forward through remote control, similar to a sideway electric scissor lift (Fig-15). This increases the distance between the magnetic box and the metal board, reducing the magnetic field and causing the container box to fall to the ground for easy retrieval by a zookeeper.