Gordon Jeon W.

The ***Definitive Guide*** *on* ***Engineering Design***

Digital Edition

THE DEFINITIVE GUIDE ON ENGINEERING DESIGN

The Definitive Guide to Engineering Design

Student Engineer Portfolio & Handbook
First Digital Edition

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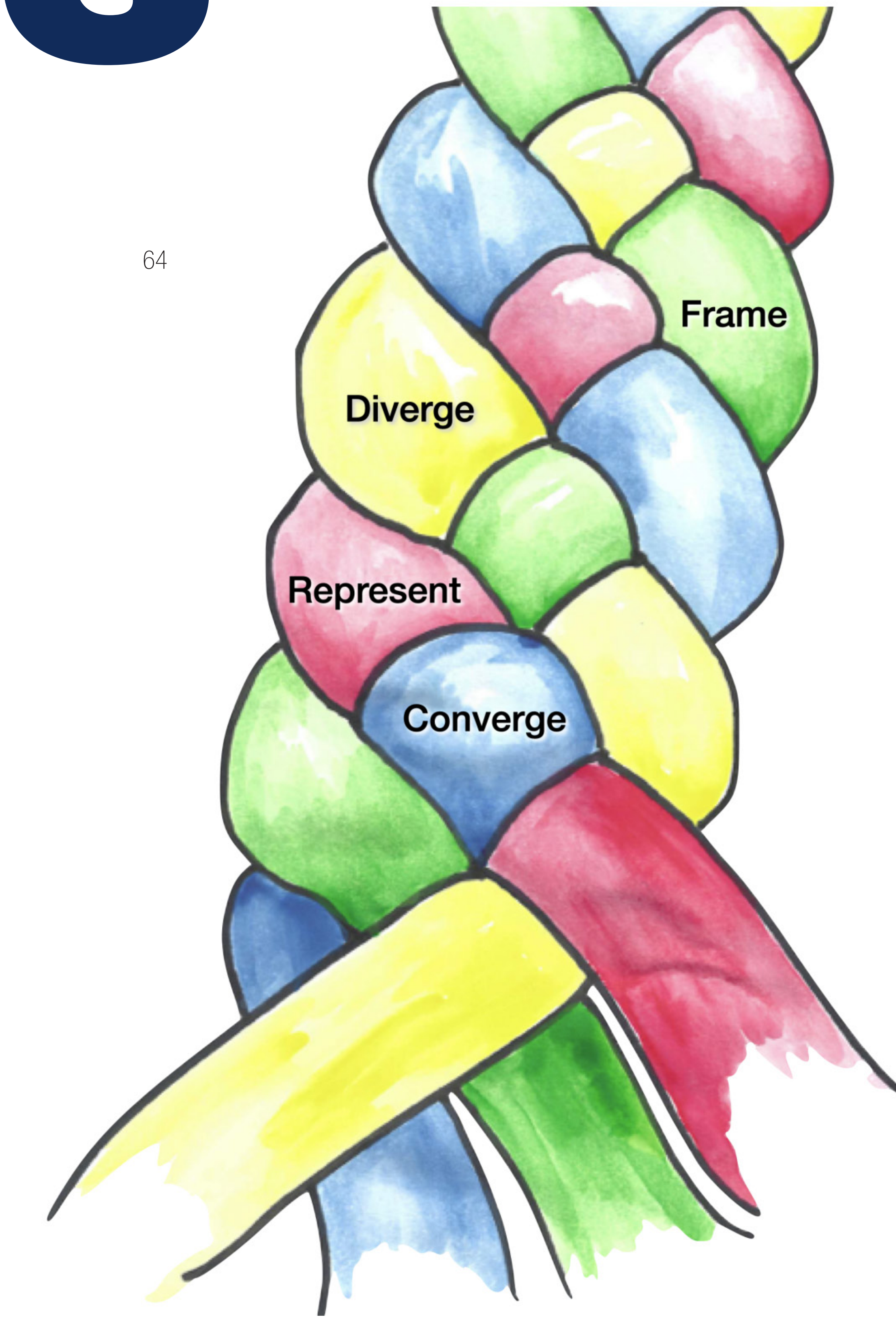
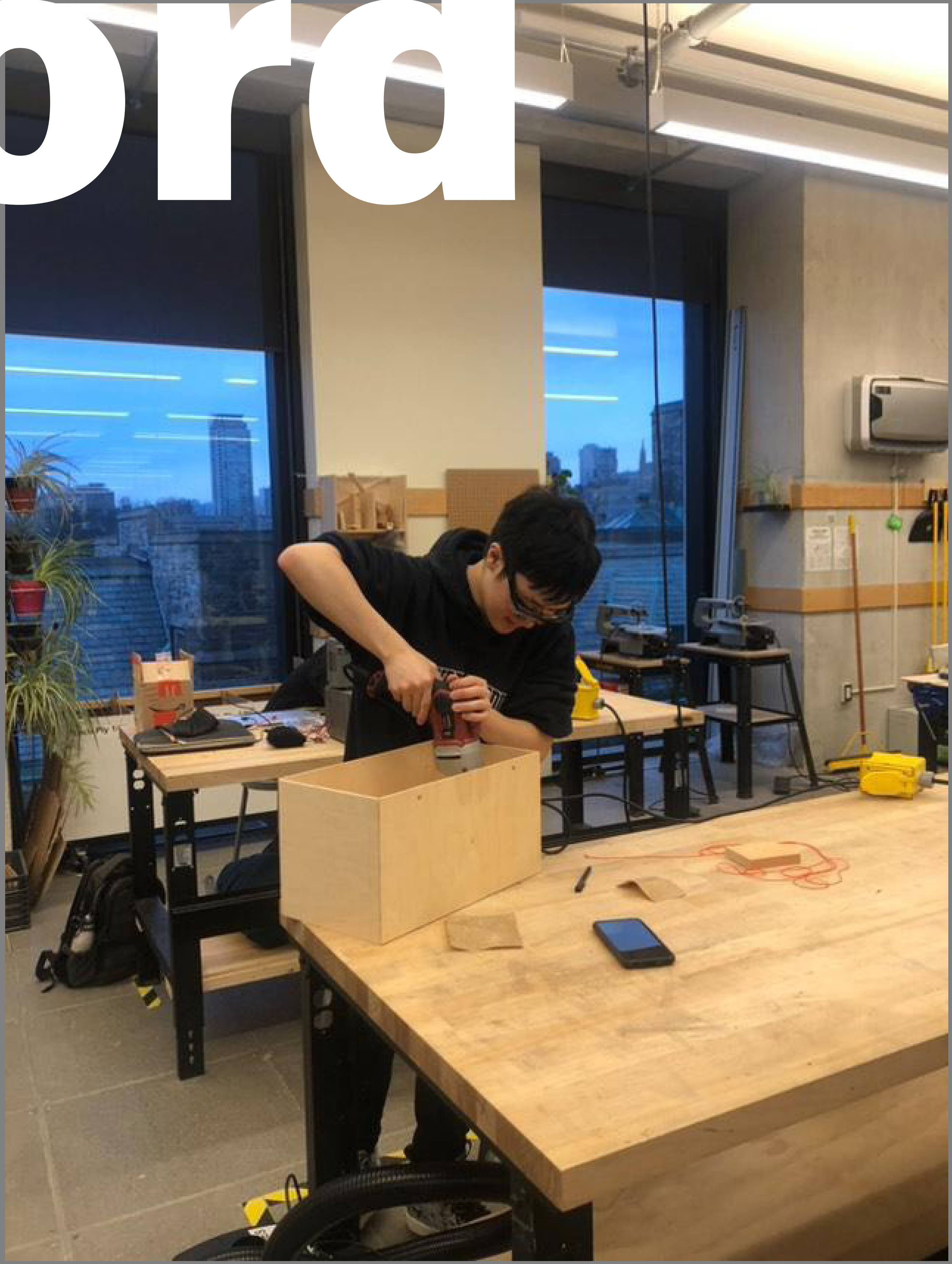


Foreword

In 2022 I was given the unimaginable privilege of getting accepted into the University of Toronto's Engineering Science Program, against all odds with over tens of thousands of other applicants whom also share my passion, not just in a STEM context, but also one of the Arts and Sciences. My first meeting with engineering design came not through my math skills or ability to code, or even my technical expertise, but through my love of solving practical problems and the discovery of the design opportunities that came with the iterative process. The idea that I could participate in the creation of works in the fields I loved and had an interest in, and on top of that share it with the world, receive feedback, praise, dislike and all of the above simultaneously on something I had passionately spent my time on. The thought of it was absolutely amazing and also had an overwhelming thrill.

This work is an ode to that fantastic world of engineering design. While this work stems from the final assignment of the University of Toronto's Praxis II course, personally I like to think it is a passion project I embarked on in hopes of creating a unified, concise and clear guide on the technical, practical and social elements of engineering design that would help any person willing to, whatever the reason, create and understand designs or participate in the discussion around the creation process, the implementation and the community around the world of engineering. In the end, this work is not perfect, nor is it all-encompassing, but instead my attempt at a guide to all things engineering design that may lead you, the reader, to a better understanding of the medium.



Me - EngSci 2T6, in the Myhal Centre Fabrication Facility (MYFab)
(Photo Credit: Iqra Khan - EngSci 2T6)

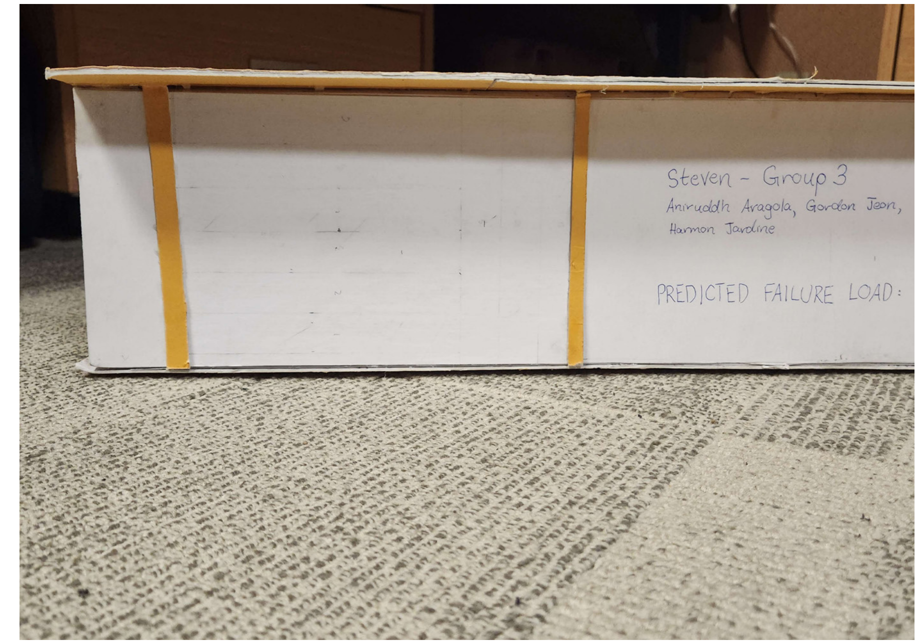
01 Technicals

Engineering Design Portfolio

1.1

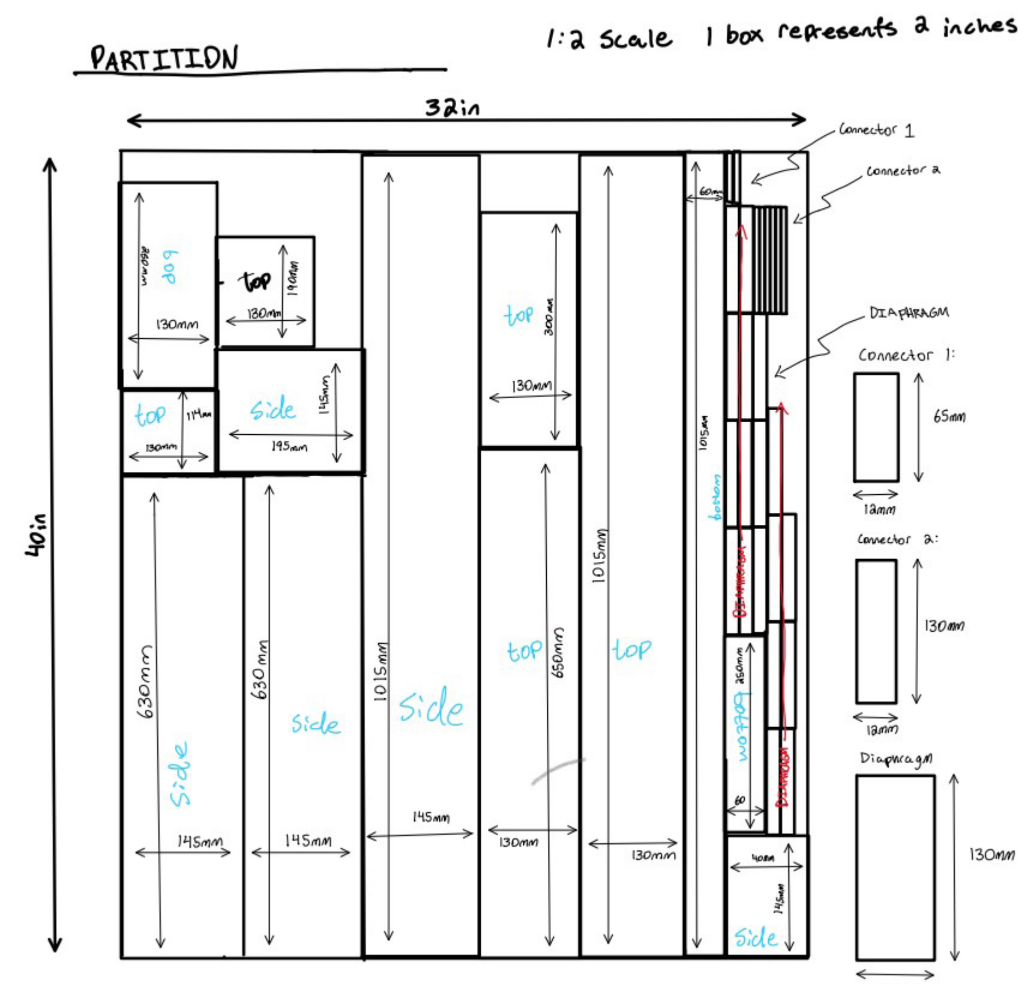
This section displays my Engineering Design Portfolio which is a curated collection of my works over the years. It is intended to showcase to the reader and external audience not just who I am as an engineering student but also the outcomes of my exertions. Included is my position in context and a summary of my design experiences and I hope any questions regarding the author is answered in this section.

Furthermore I hope this section gets you to think about your own position in context of being an engineer, i.e. I hope it gets you thinking about why you chose to be an engineer, the challenges you had to face, the things that hold you back, and they way you see engineering design every day of your life.



↑ My CIV102 group's bridge as seen from a side.
(Photo Credit: Harmon Jardine - Mech 2T6)

→ The unwrapped plan of the CIV102 bridge.



Did you know?
One of the biggest challenges my group had to overcome was the matter of rationing our materials when building the bridge. Therefore we took inspiration from 3D programs and made our layouts similar to that of the UV map: the projection of an unwraped 3D model to a 2D image for mapping textures.

First and foremost, I I assert myself as a proponent of the system of free market, free trade, free enterprise, and laissez-faire capitalism. Meaning that if I can acquire textbooks or clothes of decent quality at a cheap price, that's what I'm going to do.

That being said however, I understand there will be individuals harboring doubts and suspicions regarding my aspirations of becoming an engineer. After all, it's not uncommon for individuals to view capitalists and engineers with suspicion, as their ideologies are often seen as incompatible and both are known to have black marks in their respective histories.

But as I delve into the field of engineering, it becomes apparent that the associated expenses such as tuition costs and incidentals will get considerably high. Consequently, I find myself having to manage and ration my finances in order to prioritize my education. I'm put into a situation where, if a problem needs to be solved, I must approach it with a certain degree of compromise. This is why I am not inclined to using top-of-the-line equipment unless it is absolutely necessary.

At its core, this is why I want to pursue engineering. Looking past the soldering, machining, or being electrocuted, my values lie with me seeing engineering as a methodology to approach real world problems; I.e. I enjoy solving practical problems. However, as I undertake more projects and tackle increasingly complex problems, I'm forced to make compromises to keep costs low so as to not bankrupt the stakeholder's or even myself if it gets to that point.

↓ *"The suspended span of the Quebec bridge at the moment of collapse, at 10:50 a.m. on Monday, September 11, 1916"*
(Credit: Bibliothèque et Archives Canada)

↑ *"View of the lobby floor, during the first day of the investigation of the Hyatt Regency walkway collapse."*
(Credit: Dr. Lee Lowery, Jr., P.E. Texas A&M)

Did you know?
The Hyatt Regency collapse remains as the deadliest non-deliberate structural failure in American history. The collapse was so influential that it forced numerous institutions to rethink the culture revolving around engineering by integrating changes to engineering academia via the forum and study of engineering ethics.

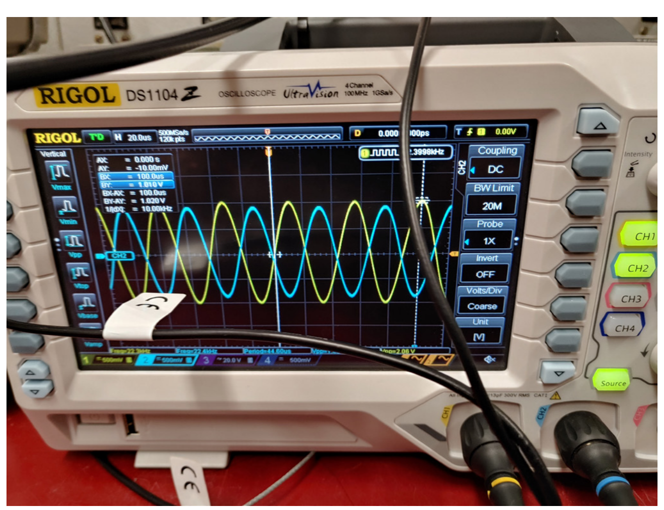
As a laissez-faire capitalist I had to learn to be smart with my money. And over the years I've learned a range of skills that translated into my post-secondary career. At the time of writing, I am still a student and as mentioned before, with it comes the associated expenses such as tuition and other incidental fees. However as I continue to develop as an engineer, my money-management skills have translated and helped in developing my skills also applicable to my academics and professional career:

→ Analytical:
  I constantly train to engage in critically thinking and break complex problems and tasks into smaller, easier components. An example is building electrical circuits where I recognize and solve the smaller sections of electric circuits before bringing them all together as a whole.

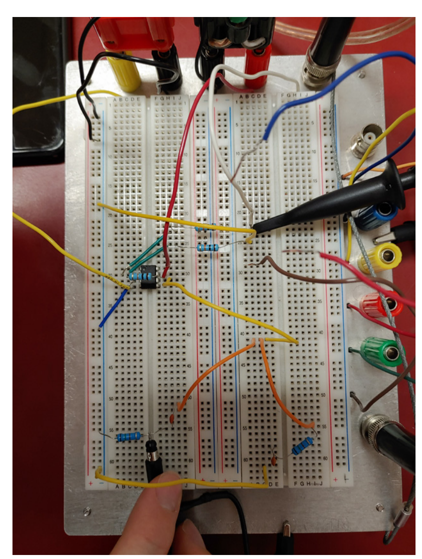
→ Problem-solving:
  I enjoy solving practical problems as to get to a solution. It may not be aesthetically pleasing but my focus is on achieving a solution that is effective and sustainable.

→ Attention to detail:
  I pay close attention to the small details in a design to ensure that it is safe, fast, efficient, and most importantly: works.

↑ There is a quote that I enjoy following: "*How am I gonna stop some big mean Mother-Hubbard from tearin' me a structurally superfluous new behind? The answer? Use a gun. And if that don't work, use more gun.*" - Engineer (Photo Credit: *Meet the Engineer)*



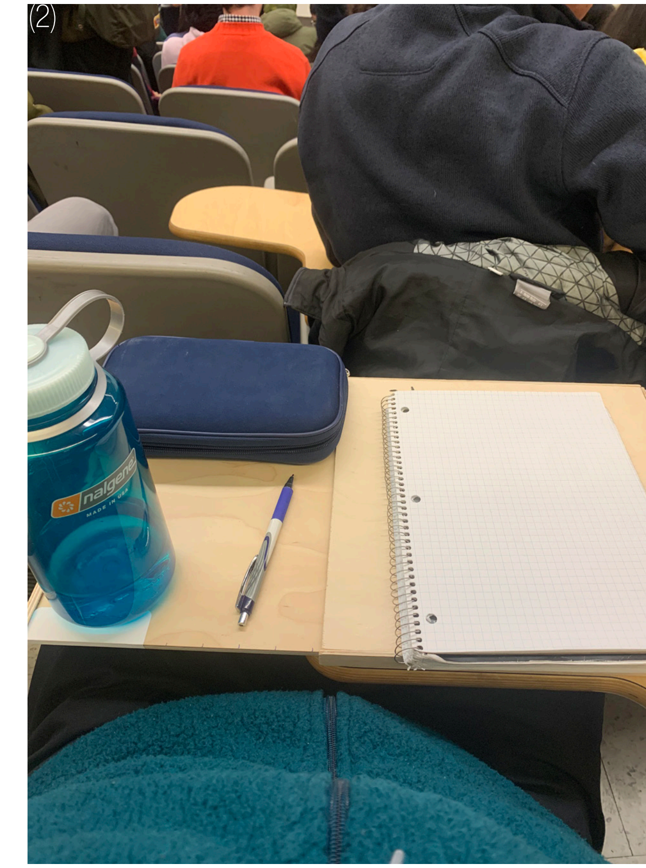
↑ Despite numerous hours being spent, breaking up each section of circuit yielded fruitful results. Shown is oscillascope displaying an alternating current.



↑ The circuit in question. Notice how each section is clearly definable and done in parts.

The early stages of the fall semester were defined by great invention and learning and by the time Praxis I got into gear, my group already proposed an opportunity: to design a portable device that improves the utilization of desk real estate in lecture halls with folding desks. (1)

The current folding desks have already proven their worth by being a surface you can write on, fulfilling the high-level objective. However we envisioned an attachment (a scaled down version) that would equal the playing field, making the folding desks' real estate comparable to the standard workstation tables one would find around campus, allowing the user for more utility.



So testing began. Protocols were made, designs were compared, and a final design was chosen. But just as the rounds of feedback were being returned. Our plan to take advantage of the student body's needs for more real estate was foiled by allusion. (2)

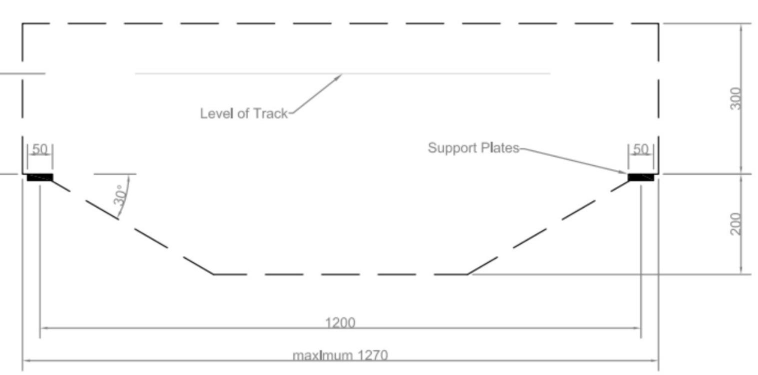
Truthfully our desk attachment was obsolescent before the opportunity became a real issue. So its hopes of surviving another bout of post-semester innovation was slim. Classrooms with the folding desks would largely stick to the original ones they had before. A design that had none of the elegance, user experience, and style, but most of the functionality at a fraction of the cost.

As the semester neared its end, our final assignments and reports were submitted and our work was evaluated. Our design's time as a potential proposal to improve the individual's classroom life was over. The design was cast aside to be laid dormant for the foreseeable future. (3)

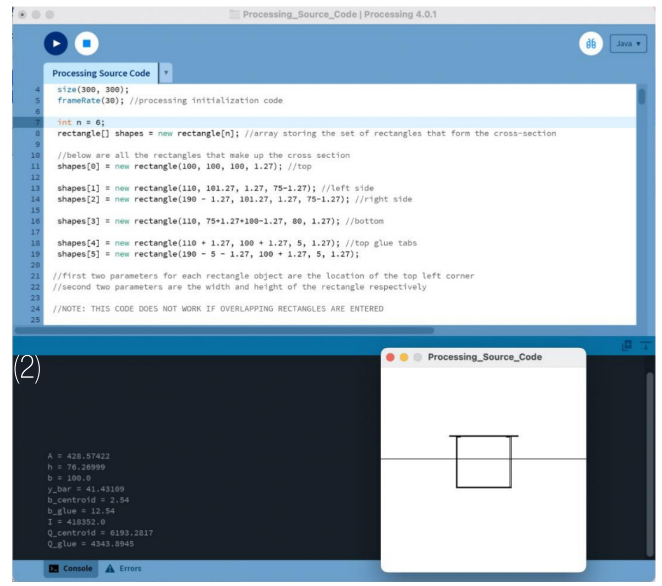
Our design filled a role that many didn't realize existed. But as a group we hoped that our design would propel us to an upper echelon of understanding engineering design. Today you can go on Amazon and buy other desk attachments that solely extend the amount of desk space, but our attachment will always have the student's need - the stakeholder's need - fulfilled as its main high-level objective. Perhaps the design was overblown, perhaps the Amazon listed reference design would do just fine. But perhaps you want to be ready for an exception.

The Desk Attachment: Future Vision, Utilitarian, Stalwart Friend

(1)



↓ (Photo Credit: Aniruddh Aragola - EngSci 2T6)



(2)

Bridges are meant to be crossed. It is their purpose, and a bridge that cannot be crossed is not a useful one. Not all are built equally, however: and the forces that drive them apart can equally unite them. But I've got to be honest, this was kind of a boring project and design-wise, my group's bridge was ugly. A couple of rectangles overlapped and held together by contact cement, as if the design was drawn and built by a child. My group has never built a bridge before, and rather than taking inspiration from the winners of the previous competitions, we decided to design our own. We were guided by the constraints and requirements set by the teaching team: the bridge had to span 1250 and 1270 mm; have a 100 mm width; permit unhindered passage of the train; and have no obstructions for the wheels of the train to roll over. Unhindered by any preconception nor experience of bridge-building, we set off to build what was an entirely new bridge, designed to an exacting specification. (1)

The planning phase began with a mountain of calculations. Stress, strain, axial forces, flanges, buckling, and factors of safety. There was an overwhelming amount of planning before we even got to thinking about building, but this was crucial as it opened our eyes to the scope of our capabilities; what we could do and what we couldn't. And one we settled on a design, we found it turned out to be a hollow structural section (HSS). (2)

So construction began but no testing could be done. This was our one shot, and following the exacting specifications of our design, with the time against us, we managed to build a bridge. Our calculations looked promising but we had low hopes and we soon found that things considered "good enough" are rarely ever the case. (3)

(3)

Testing day ended with our bridge passing the lowest bar of achievement. However in our eyes we didn't see this as a complete failure. Not only was it an excellent learning experience where we applied our civil engineering knowledge, but it opened our eyes to the reality of engineering design. Our bridge might have been home-grown, but when faced with plainly better alternatives, "good enough" wasn't nearly good enough. Still, it may have been a stress-fueled stopgap; a mishmash of finals-season design; and a mascot of an unpopular course, but the bridge still performed its duty. Some loved it, others hated it - but our bridge never failed to make an impression. An imperfect design, not without flaw - but a design nonetheless.

The Bridge: Time-Tested, A Course's Tradition, No Finer Implement of Learning

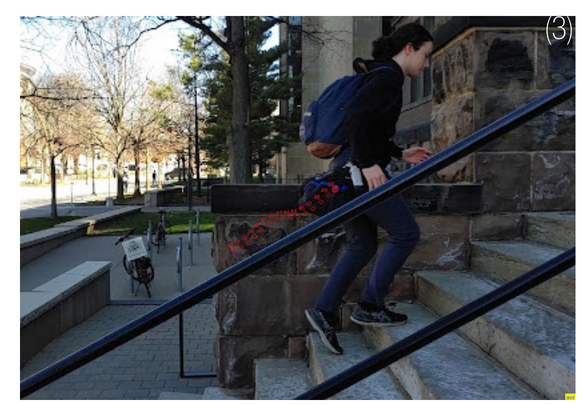
(1)

You are afraid. Amber lash of searing flame, lungs filled with acrid smoke. And as the fire is spreading, eating away at the infrastructure around you, find yourself fumbling with the bag carrying the tools you need to take it out; this is the opportunity that would be bestowed on my group during Praxis II: the redesign of the method of transporting standpipe equipment during firefighter use.

Our interest in a more critical mission led us to choosing the Toronto Fire Service as the community we would assist. After the first round of meetings with the community, the first responders expressed an interest in developing a better way to carry their equipment during their missions to combat fires, to replace the standalone kitbags currently in service. (1)(2)

(2)

Over the course of consulting multiple diverging and converging techniques, we settled on a design that checked all the boxes. This would permit a more comfortable, easier to carry bag than would otherwise be possible with existing reference designs. However later design prototypes were made to reliably function with the equipment the firefighters already had - and given the fire service's existing stocks, and unwillingness to retrain their firefighters - this proved a decisive factor in the design's selection as the Beltbag. (3)



(3)

One of the most notable features of the Beltbag is its method of carry: instead of carrying it on your shoulder like a traditional messenger bag, it was carried on the waist below the oxygen tank of the user, as if it were directly attached to the derriere of the user rather than the belt. This quirk is well-remembered and is a symptom of our iterative process. We really thought our beltbag was ahead of its time. Furthermore, with additional rigorous tests, we concluded it had to be the first successful design that was both comfortable and could carry the necessary equipment required by the user. It gave the users that wielded it a distinct advantage in terms of user experience as opposed to the existing solution. (4)

← Testing the Beltbag in Tracker
→ The Beltbag as a medium fidelity prototype

(4)

So as dull as bags can be, there's something to like about the Beltbag. A utilitarian charm. It's jus
extraordinary well. It's lost its exotic edge - no longer is it the uncomfortable mess that changed the outlook on firefighting equipment - but it's matured into a modern piece of equipment that might just save the lives of others. So, welcome to the "President's Choice". A versatile bag with a potentially broad appeal. It's true, there are better looking bags out there and some more suited to specific missions. But the Beltbag is the stopgap that is "Good enough" to do good enough. Besides, sometimes unconventional is beautiful and sometimes boring is exactly what you need.

The Beltbag: Comfortable, Effective, Universal

1.2 Questioning **Credibility** and **Legitimacy** of a **Claim**

This section gives an introduction to the foundations of upholding, understanding, and recognizing credibility and questioning the legitimacy of a claim. This is important because, as engineers, credibility serves as a foundation of trust between the engineer and the stakeholder. It serves as a testament of our responsibility as engineers and shows our competence and ethical practice in relation to our work.

Furthermore, recognizing the legitimacy of a claim is crucial as it effects the decision making process such that it is supported with evidence and justification.

This topic will be expanded further in the CRAAP test as the verification of a source is analyzed.

→ Shown is the *Toulmin's Structure of Argument* as taught in the University of Toronto's Praxis I course. (Credit: R. Irish and P. Sheridan, "Yet another Foundational Model - Every aspect of design involves "argument", in Praxis I, 13-Apr-2023.)

Did you know?
Another precondition you could consider is the **rebuttal** or **counterclaim**. This involves recognizing and acknowledging the existence of an alternative but valid view of the situation. Affirming the existence of such qualifiers and rebuttals builds your credibility as an unbiased and conscientious thinker.

The main takeaway of me listing these strengths is as follows:

"This what worked for me. These may not necesarrily work for you. You should find something that works for you, yourself. But hopefully this will help".

The process of engineering design is so holistic and comprehensive that everyone has a different way of approaching an opportunity and this will be further expanded in the sections regarding the FDCR strands.

Furthermore this is a sign that you should not take the ideas mentioned in this handbook as word, i.e. you should not believe or accept what someone says as true without questioning it or seeking further evidence to confirm its accuracy. What you are essentially doing is taking what is said in this handbook at face value, without any critical evaluation or analysis.

An excellent tool you can use to avoid or potentially circumvent this issue completely is consulting the *Toulmin's Structure of Argument* and it breaks down into the following preconditions and considerations:

The **claim** is the assertion that authors would like to prove to their audience

The **grounds** is the underlying evidence and facts that help to support the claim (think of it as the initial stages of supporting evidence)

The **justification** is the assumption that links the ground to the claim (it should be treated as a thorough overall argument to the claim)

The **evidence** is any additional support for the justification (in many cases the justification is implied, and the evidence gives a specific example to argue for it)

The **qualifier** displays to the reader that the claim may not be true in all circumstances. It shows not only that you are aware that your argument may be wrong but also the acknowledgement of any potential biases that you may have

The gauge of craziness for a claim
(Credit: R. Irish and P. Sheridan, “Yet another Foundational Model - Every aspect of design involves “argument”, in Praxis I, 13-Apr-2023.)

Did you know?
You may debate on whether or not select claims are objects of Logos, Ethos, or Pathos. A good way to remember is to remember the following shorthands:

Analytical Claim: Answers “What?”
Important to generate understanding
Mostly evidence based

Interpretative Claim: Answers “So what?”
Important to generate agreement
Mostly justification soft logic

Speculative Claim: Answers “What could be?”
Important to generate ideas
Mostly justification, more qualifiers

As you progress your learning in engineering design. Your encounters to claims that appear increasingly implausible will become a common occurrence. As such, it is wise to familiarize yourself with the various types of claims that you may come across:

- Analytical Claim:
  These claims break down ideas that you might find complex or overwhelming into smaller parts for a better/more intuitive understanding. They answer the “What?” questions and are vital for generating understandings. Note how analytical claims rely on the Logos of of logical reasoning.
- Interpretive Claim:
  These claims are often subjective are intended to explain the meaning and/or significance of a medium. They answer the “So What?” questions and are vital for generating agreements between parties. Note how interpretive claims are subjective and rely on the Pathos of emotional connection.
- Speculative Claim:
  The claims aim to propose a hypothesis or theory for arguments which may not have a direct solution or may not be easily provable. They answer the “What Could Be?” questions and are v vital for generating ideas. Note how speculative claims may require the credibility of Ethos in order to prove the aforementioned hypotheses and theories.

Think. What are some ways to ***support*** a **claim?**

“Regardless of how outrageous or what type a claim may be, the further a claim is from the ground the more evidence and justification is required for it to be acceptable.” - R. Irish

There are many ways to support a claim but most of them break down to research, testing, calculating, making models, and building low-fidelity protoypes to display a proof of concept.

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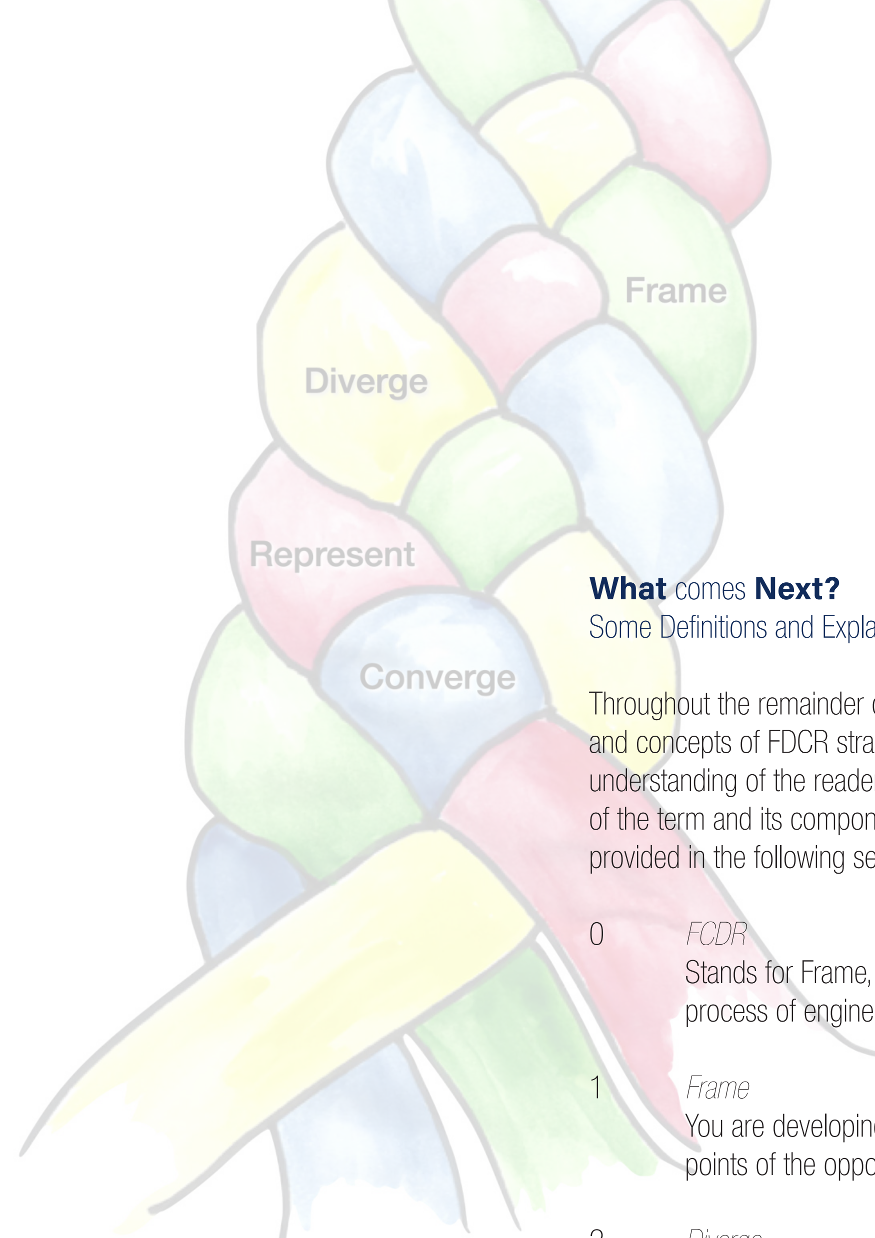
An **Overview** on **Engineering Design** 1.3

Congratulations, you have made it to the Overview. From here the ride truly begins where I hope you learn the intricate ins and outs of engineering design. My goal from here is to be as brief but comprehensive as possible in the hopes that you, the reader, will engage in transparent conduct as you develop your knowledge and practice as an engineer and as you engage in engineering design.



Did you know?
It isn't rare for people to forget definitions and I see repetition as part of the learning experience. Feel free to bookmark this page if for any reason you feel the need to refresh your memory. This is what builds the foundation to engineering design.

What comes **Next?**
Some Definitions and Explanations

Throughout the remainder of the book, I will often refer to the various theories and concepts of FDCR strands and in order to provide clarity and maintain the understanding of the reader, I deemed it suitable for me to include the definitions of the term and its components here. In-depth explanations to its components are provided in the following section:

0 *FCDR*
Stands for Frame, Converge, Diverge, Represent. Makes up the iterative process of engineering design.

1 *Frame*
You are developing a narrative to better understand and highlight the key points of the opportunity.

2 *Diverge*
You are generating ideas and evaluating as many possible solutions as possible. You are also generating said ideas on the basis that you are following the requirements model.

3 *Converge*
You are throwing some ideas away to hone in on a potential solution. You are also refining the solution and finding a way for the stakeholders to properly implement it.

4 *Represent*
You are further refining your solution in order to make it the best possible but also feasible. This is done via fidelity prototypes, further research, further planning, sketches, and presenting an argument for why such solution is the best solution.

02

Framing

Framing the **Opportunity**

2.1

In engineering design, engineers are put into situations where they will have an opportunity to solve a problem. The opportunity here refers to the engineer having the chance to design a new solution or improve the already existing solution(s) set in place.

These opportunities require engineers to hone their skills and creativity to develop a design that will serve as the solution to the opportunity, all to meet the needs of the stakeholders.

By retaining these opportunities, not only do engineers grow as a member of the workforce, but they are also contributing to the advancement of their field and emphasizing their value to the stakeholder as a valuable connection/asset.

Design a portable object expanding available desk-space in tablet-arms
Total Word Count: 1786

1. Introduction: Limited Desk-Space in Certain Lecture Halls

This design brief describes an opportunity for a design that could improve the desk-space for lecture halls in the University of Toronto ("UofT") without renovation. Some lecture halls do not provide the necessary workspace for students to learn effectively. While these lecture halls do include a surface for students to use such as the rotary arm desk (hereinafter referred to as "tablet-arms"), they cannot accommodate for students who require more spaces to learn due to insufficient desk area. Therefore, this document presents the issues related to the tablet-arms currently installed in various lecture halls, the major stakeholders whom the designs must satisfy, and the requirements for solutions considering the stakeholders, reference designs, and

↑ Above is my Design Brief written for Praxis I and it served as the foundation for our framing phase.

The Requirements Model

Components Summary

The requirements model is a structured representation outlining the needs of the stakeholder and it serves as the blueprint for the designing, testing, development, and validation of your solution. Furthermore there are certain vocabularies in the requirements model that dictates the outcome of your solution. Be sure to assess the requirements model carefully as it can be the make or break between you and the final design.

The requirements model typically consists of the following components,

Stakeholders
Objectives
Metrics
Constraints
Criteria

and as mentioned before these aspects will dictate the decision making process when you converge towards your final design.

You should note however that on rare occasions you will not be able to meet all the aspects of the requirements model and as an engineer it is crucial you understand and take into account of both the theoretical ideal and the practical reality. You should strive to find a balance between the two that not only works for you but will accepted by yours peers and the stakeholders you work with, this balance is paramount to your success as an engineer.

3. Identifying Stakeholders Needs
Ranked by importance, the students who desire more desk-space are the main stakeholder followed by caretakers who maintain the facilities, neighbouring students who also participate in lectures, and the design team who meets the demands of other stakeholders.

3.1 Students who desire more desk-space
Students attend the lecture halls to learn. As current tablet-arms has limited desk-space, an improved design should be comfortable, accommodate desired learning materials and have a convenient assembly process.

3.2 Caretakers
Caretakers maintains classrooms, so ease of maintenance is a concern. The designs should should not damage lecture hall.

3.3 Neighbouring students
Other participants of lectures also possess a stake within this design. Their ability to learn in lectures can be negatively impacted by:

- Loud noises
- Invasive physical contact

Accordingly, the designs should avoid having above characteristics to avoid inconveniencing neighboring students.

↑ Above is an excerpt from my team's Praxis I design brief. An explanation of our stakeholders and how we found is shown. Notice how we tried to account for every single party that would be impacts by our design.

The Requirements Model
Stakeholders

The stakeholder refers to any individual, group, or organization who impacts or is impacted by the final design. Typically, stakeholders have different interests and priorities depending on the subject matter of the opportunity but it is your job as an engineer to ensure that all stakeholders' needs and expectations are met.

Furthermore, your final design should consider the feedback and input from the stakeholders themselves as doing so allows you to make any necessary changes based on their feedback.

On rare occasions you may run into the event where the stakeholders' input doesn't align with the requirements model initially set. This is OK. Engineering design isn't a set-to-stone process and making changes is acceptable such that the stakeholders' needs are met.

Did you know?
Something to keep in mind is that as a member of the design team, you are also a stakeholder. This is because you have a significant impact on the success of the project. Furthermore, the design team is responsible for designing solutions for the stakeholders, often having limited time to complete the task.

Objective
Increase usable desk area *High level objective: expand desk-space*
Not infringing with neighboring students' space. *Preventing distractions to neighboring students*
Minimize cumulative set-up and takedown time *Minimizes class time loss.*
Can be set up without use of tools *Student stakeholders should not be required to bring special tools to set up the design*

The Requirements Model
Objectives

The objective breaks down to what the design should do or be. As per the requirements model, objectives are established early in the design process and can sometimes be confused with the requirements. But either way the objective helps in ensuring that the final design meets the desired result.

← Note how the accompanying image has "High level objective" in the second cell. This is because objectives typically divvy into categories: high-level, low-level, etc. The high-level objective is indicative of and overarching and/or broad goal, in this case to expand the desk space. The low-level objective investigates the specific goals; targeting the specific details of the requirement. These derive from high-level objectives but are more actionable/direct to work with.

The Requirements Model
Metrics

Metrics are often quantitative measurements used to evaluate the characteristics of a design. They provide an excellent way of gauging how alternative designs measure.

→ Note how the accompanying image has a Yes/No metric in the fifth cell. This is to portray the characteristics of metrics themselves and how they don't always have to be a quantitative measure. When analyzing metrics, it's good to remember the following:

0 *Assess*
Assess the design to enable evaluation

1 *Look*
Look out for characteristics + units (i.e. Volume + Liters)

2 *Ask*
Ask yourself about the nature of the metric. It should be relevant, comparable and credible

Metric
Total combined area of flat surface of original tablet-arm and design (in^2)
Horizontal dimensions of design ($cm \cdot cm$) *Design likely intruding neighboring students' space in horizontal direction*
Cumulative time to set up and take down the design (min)
Yes/No

Objective	Metric	Constraint
Reusable *Save students' costs*	Mean uses to Failure *Quantifies longevity, service life, and quality of design*	
Support uniformly distributed load *Most objects on desks are uniformly distributed loads*	Max UDL before permanently deforming (KPa). Using adapted version of ISO 21016:2007 section 6.1.1.1 following 4.4 [7]. Testing vertical loads by incrementing uniform loads of approximatively 100 Pa across design's surface.	Should be greater than 5.7 KPa [Appendix B]
Support point load *Conditions which induce greatest bending*	Max point load before permanent deformation (N). Using adapted version of ISO 21016:2007 section	Should be greater than 333N [Appendix B]

← Again, note the use of the vocabulary "should". This indicates a cut-off with tolerance. Furthermore note how included is a reference to the appendix: [Appendix B]. There is supporting information that suggests the validity of the argument.

Did you know?
Must, Must Not, Should, Should Not

These terms are known as the RFC keywords and they are used to "signify the requirements in the specification".

(Credit: S. Bradner, Key words for use in RFCs to Indicate Requirement Levels, 15-Apr-2023.)

The Requirements Model
Constraints

The constraints are the limitations or restrictions that must be taken into account when designing the solution. The importance of constraints cannot be understated as failing to take them into account can result in the design missing the mark by not meeting the requirements of the opportunity. You should be constantly asking yourself: "Is this alternative viable?"

Another characteristic of the constraints you should take into account is the vocabulary used. You will often see words such as "Should not be" or "Must not". "Must" here defines the constraint to be characterized by a hard number. Furthermore "Should" and "Must" are indicative of the type of cut-off:

- Should: Cut off with tolerance → allows the possibility of doing something different if there is an accepted supporting argument
- Must: Hard cut-off

The Requirements Model
Criteria

The criteria are the set of requirements that a potential solution must meet to be considered successful. They are guided by the other components of the requirements model such as the constraints and objectives and are further tailored to account for any applicable regulations, standards, specifications, etc. When analysing criteria, ask yourself: "How do these alternatives compare?". It is also good practice to remember the following:

0 *Want*
Want more or less

1 *Determine*
Determine the relationship between measurements (usually 2) → likely represented as {better, same, worse}

↓ Notice the use of {better, same, worse}. We're able to get a guesstimate on how the potential solution should be molded

Objective	Metric	Constraint	Criteria
Reusable *Save students' costs*	Mean uses to Failure *Quantifies longevity, service life, and quality of design*		Greater is better
Support uniformly distributed load *Most objects on desks are uniformly distributed loads*	Max UDL before permanently deforming (KPa). Using adapted version of ISO 21016:2007 section 6.1.1.1 following 4.4 [7]. Testing vertical loads by incrementing uniform loads of approximatively 100 Pa across design's surface.	Should be greater than 5.7 KPa [Appendix B]	Greater is better
Support point load *Conditions which induce greatest bending*	Max point load before permanent deformation (N). Using adapted version of ISO 21016:2007 section 6.1.1.1 following 4.4 [7]. Testing vertical loads by incrementing approximatively 10N force at point furthest from supports.	Should be greater than 333N [Appendix B]	Greater is better

2.2 **Credibility** and the **CRAAP** test

In all fairness the CRAAP test doesn't deserve an entire section to itself, however it is an immensely powerful tool when assessing the credibility of a source. This section is intended to provide a criterion of the CRAAP test.

Standing for Currency, Relevance, Authority, Accuracy, and Purpose, the CRAAP test is a test used to evaluate the credibility of sources of information.

CRAAP Test: Helpful criteria for evaluating your sources:

→ *Currency: The timeliness of the information*
- When was the information published or posted?
- Has the information been revised or updated?
- Does your topic require current information, or will older sources work as well?

→ *Relevance: The importance of the information for your needs*
- Does the information relate to your topic or answer your question?
- Who is the intended audience?
- Is the information at an appropriate level
- Have you looked at a variety of sources before determining if this is online you will use?
- Would you be comfortable citing this source in your paper?

→ *Authority: The source of the information*
- Who is the author/published/source/sponsor?
- What are the author's credentials or organizational affiliations?
- Is the author qualified to write on the topic?
- Is there contact information, such as a publisher or email address

→ *Accuracy: The reliability, truthfulness and correctness of the content*
- Where does the information come from?
- Is the information supported by evidence?
- Has the information been reviewed or refereed?
- Can you verify any of the information in another source or from personal knowledge?
- Does the language or tone seem unbiased and free of emotion?
- Are there spelling, grammar or typographical errors?

→ *Purpose: The reason the information exists*
- What is the purpose of the information? I sit to inform, teach, sell, entertain or persuade?
- Do the authors/ sponsors make their intentions or purpose clear?
- Is the information fact, opinion or propaganda?
- Does the point of view appear objective and impartial?
- Are there political, ideological, cultural, religious, institutional or personal biases?

LOEX Quarterly Volume 31

The CRAAP Test

Sarah Blakeslee

California State University, Chico

Sometimes a person needs an acronym that sticks. Take CRAAP for instance. CRAAP is an acronym that most students don't expect a librarian to be using, let alone using to lead a class. Little do they know that librarians can be crude and/or rude, and do almost anything in order to penetrate their students' deep memories and satisfy their instructional objectives. So what is CRAAP and how does it relate to libraries? Here begins a long story about a short acronym…

Last spring while developing a workshop to train first-year experience instructors in teaching information literacy, I tried to remember off the top of my head the criteria for evaluating information resources. We all know the criteria I'm referring to. We've taught them a hundred times and have stumbled across them a million more. Maybe we've read them in our own library's carefully crafted evaluation handout or found one of the 58,300 web documents that appear in .23 seconds when we type "evaluating information" into the Google search box (search performed at 11:23 on 1/16/04). Most of these documents follow a similar theme. After convincing us of the necessity of evaluating information, or warning of the dangers of not evaluating information, they list five (or is it six) keywords or criteria,

Early Alzhiemer's seemed unlikely, as I still maintained a pretty good record for showing up at the reference desk during my appointed shifts. And I could always comfort myself with the oft-quoted (at least by librarians) words of Samuel Johnson if I could only remember what they were. You know the one I mean, something about being ok as long as we know where to go to find information even if we don't know it ourselves. Certainly, as evidenced by my successful Google search, I knew where to go to find the information I needed about evaluating information. But what about my students? Would they be as successful? If I couldn't remember these important criteria when I worked with them almost daily how could I expect my students to remember them?

I had no doubts concerning their capabilities in Googling in the same brilliant way as I, but I did have some nagging doubts about their motivation to do so. Did I trust them to hold up a piece of information, to ponder, to wonder, to question, and to remember or seek the criteria they had learned for evaluating their source that would instantly generate the twenty-seven questions they needed to ask before accepting the information in front of them as "good"? Honestly, no, I didn't. So what could I do to make this information float to the tops of their heads when needed? Musing over handouts and web pages from libraries across the country, looking

← An excerpt from the original published document. It's a fun read. (Credit: Blakeslee, Sarah (2004) "The CRAAP Test," LOEX Quarterly: Vol. 31: No. 3, Article 4. Available at: https://commons.emich.edu/loexquarterly/vol31/iss3/4)

03

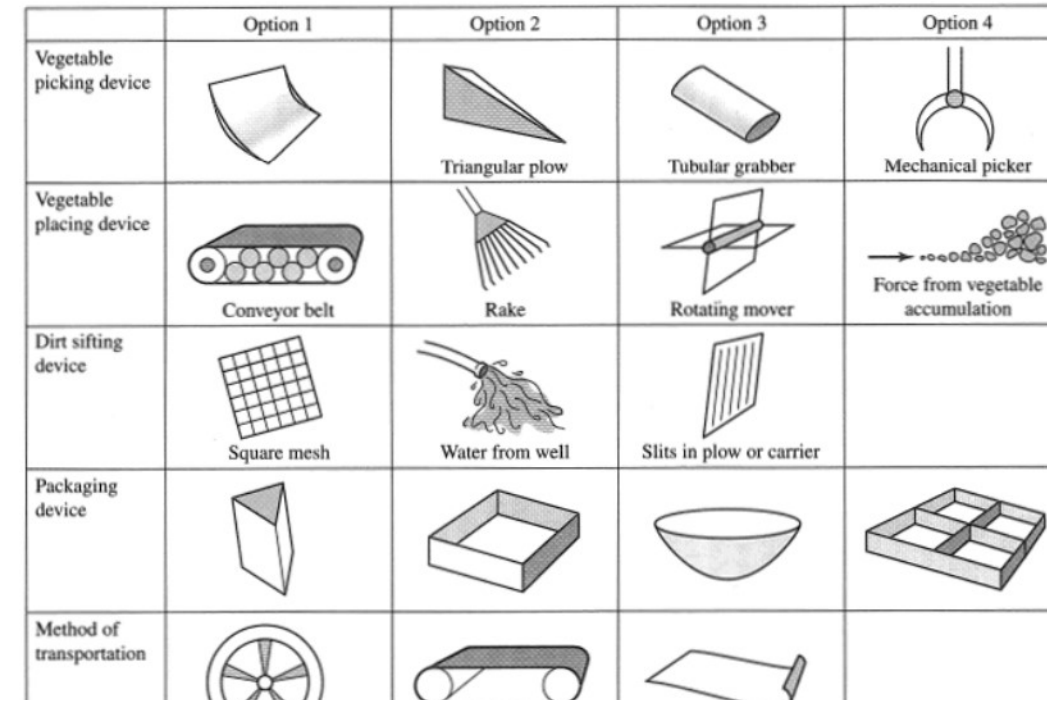
Diverging

Diverging Tools

3.1

As discussed earlier, the process of diverging revolves around the generation of ideas and to generate ideas, you will need to consult a few tools. This section will briefly go over the concepts and use of design mediation tools such as morph charts and a mnemonic tool called SCAMPER.

→ Here is a morph chart used in Praxis I. Notice how every single aspect is considered and drawn. From here its all a matter of making combinations and checking their feasibility.
(Credit: R. Irish and P. Sheridan, "Thinking to Ideate &
Building to Think", in Praxis I, 18-Apr-2023.)



Diverging Tools
Morphological Charts

Morph charts are used to systematically explore the design space and generate a wide range of potential solutions. It looks at design mediation by breaking up the opportunity we are designing for into subcomponents (This contrasts to the diverging techniques discussed in the next section). Moreover, this tool is excellent for getting into the nit-picky levels of engineering design, where it is expected you will be more precise and detailed in your decision making process. This is because it allows you to target specific aspects for change rather than altering the potential design as a whole. The process of utilizing a morph chart is as follows:

0 *Think*
Think of the aspects/features of what you are trying to design. Try to identify as many as you can, from functions to sub-functions

1 *Ideate*
Ideate along each of the individual aspects to think of ways you could implement them in a design, you will have a lot of these

2 *Create*
Create a comparison matrix with all the possibilities by aspect and fill the rows with the aspects that belong to a particular metric/feature

3 *Explore*
Start drawing and exploring different possible combinations of the features by row and column and evaluate if its feasible with respect to the opportunity

SCAMPER Guidelines & Example (Innovate the sales approach)		
S	Substitute	Think about substituting part of your product/service or process for something else. By looking for something to substitute, you can often come up with new ideas. **Typical questions:** What can I substitute to make an improvement? What if I swap this for that and see what happens? How can I substitute the place, time, materials, or people? **Example:** Online training, Chat sessions with the trainer, Conferences (video, audio), Computer-based training, Library (eLibrary, physical library), Self Study by employee, On-the-job training, Recorded classroom (available 24X7, divided in slots), Anyone can attend any module twice, Group discussion, Mail based training.
C	Combine	Think about combining two or more parts of your problem to create a different product/process or to enhance synergy. **Typical questions:** What materials, features, processes, people, products, or components can I combine? Where can I build synergy? **Example:** Combine classroom training with On-the-job training, Library studies and trainer/conferences, Self study and online trainer/conferences, Combine locations (Reduce number of locations), Combine induction and training wherever possible, Combine work with training, Mix people (trained and untrained) then trained people will train untrained people.
A	Adapt	Think about which parts of the product/service or process could be adapted to remove the problem, or think how you could change the nature of the product/process. **Typical questions:** What part of the product could I change? And in exchange for what? What if I were to change the characteristics of a component? **Example:** Notes exchange between participants, Convert training material to drawings/flip charts, Mix people (trained and untrained) - then trained people will train untrained people, Video of one-training/one-trainer then replicate and distribute (reuse).
M	Modify	Think about changing part or all of the current solution to distort it in an unusual way. By forcing yourself to come up with new ways of working, you are often prompted into an alternative product, service, or process. **Typical questions:** What happens if I warp or exaggerate a feature or component? What will happen if I modify the process in some way? **Example:** Change training delivery media, Classroom to computer-based training, Classroom to audio/video training, On-the-Job Training, Change mode of training, Paper/pencil to Web-based learning, Classroom to audio/video training, Reduce locations of training, Increase batch size, Intensive training, Anytime training.
P	Put to other purposes	Think of how you might be able to put your current solution to other purposes, or think of what you could reuse from somewhere to solve your innovation problem. You might think of another way to meet your Job To Be Done or find another market for your product. **Typical questions:** What other market could I use this product in? Who or what else might be able to use it? **Example:** Use training material as reference in library, Training in auditorium, Training in movie/drama format, Training in game/puzzle format, Part training to set of people - then each set becomes internal trainer for the part it learned and trains others.
E	Eliminate	Think of what might happen if you eliminated various parts of the product/process/problem, and consider what you might do in that situation. This often leads you to consider different ways of tackling the problem. **Typical questions:** What would happen if I removed a component or part of it? How else would I achieve the solution without the normal way of doing it? **Example:** No classroom, Training without classroom, No trainer, Virtual trainer, Eliminate time constraint, Anytime training, Video of one-training/one-trainer reuse - replicate the same.
R	Reverse	Think of what you would do if part of your problem/product/process worked in reverse or was done in a different order. What would you do if you had to do it in reverse? **Typical questions:** What if I did it the other way around? What if I reverse the order it is done or the way it is used? How would I achieve the opposite effect? **Example:** Learner is trainer, Create trainer, Create library, Prepare training and trainer in-house.

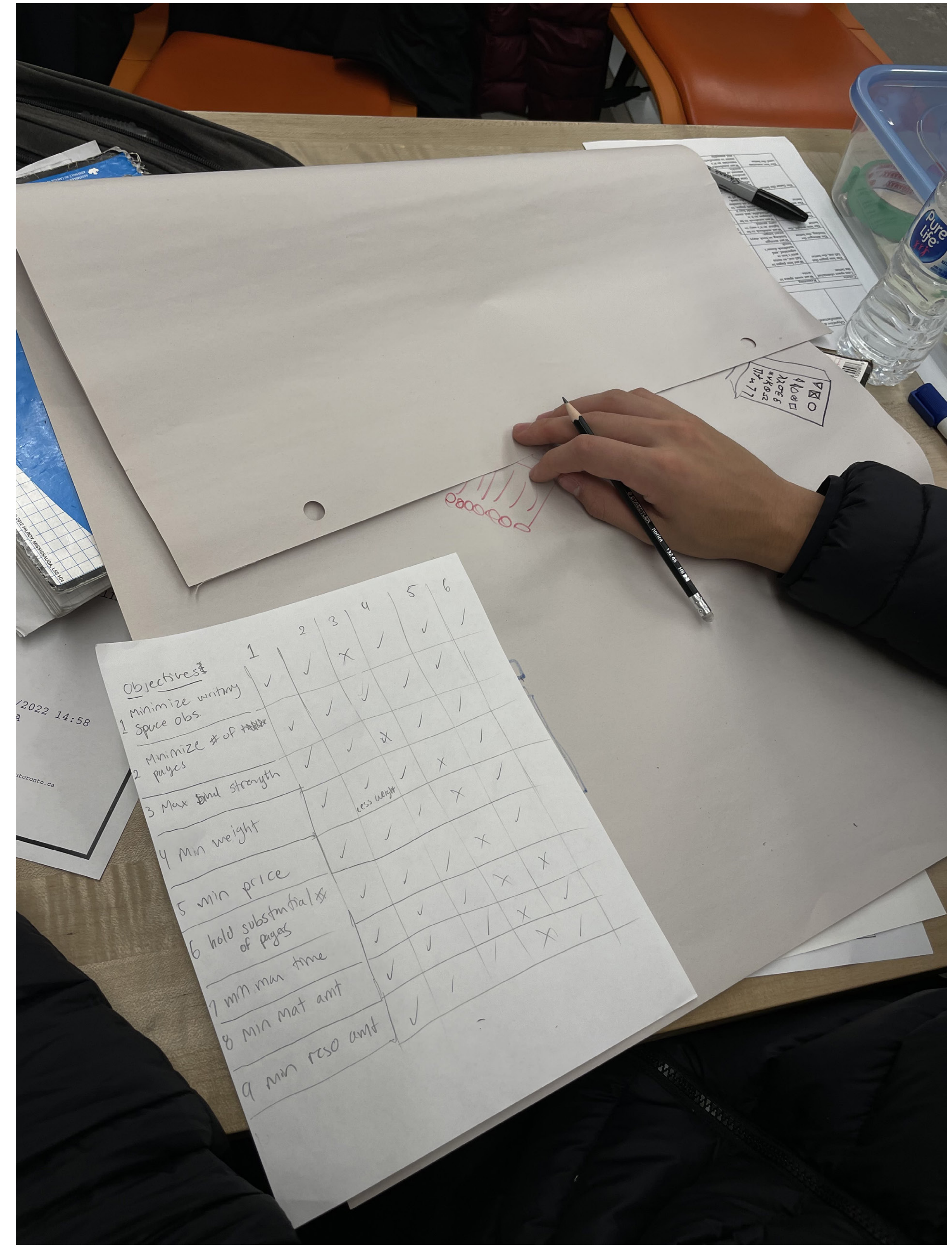
← SCAMPER criterion from Praxis I (Credit: R. Irish and P. Sheridan, "Thinking to Ideate & Building to Think", in Praxis I, 18-Apr-2023.)

Diverging Tools
SCAMPER

Standing for Substitute, Combine, Adapt, Modify, Put to other purposes, Eliminate, and Reverse, SCAMPER enables the designer to analyze the individual aspects developed for the morph chart. Usually SCAMPER comes after the morph chart to maintain the brevity/cohesion of analysis.

SCAMPER makes you ask questions such as "Are there approaches that should be substituted for others in your existing design?" or "If you select a specific approach and emphasize it what effect will that have on the other aspects/actions?" in order to draw connections between your diverging phase and what your final design is going to do.

Are you on the right track? Maybe if you changed this or removed that? SCAMPER is all about making you question your choices in order for your design to better fit the opportunity. Don't be afraid to dig into the nitty-gritty details, it will all be worth it as the end as what you have essentially have done is considered all the possibilities.

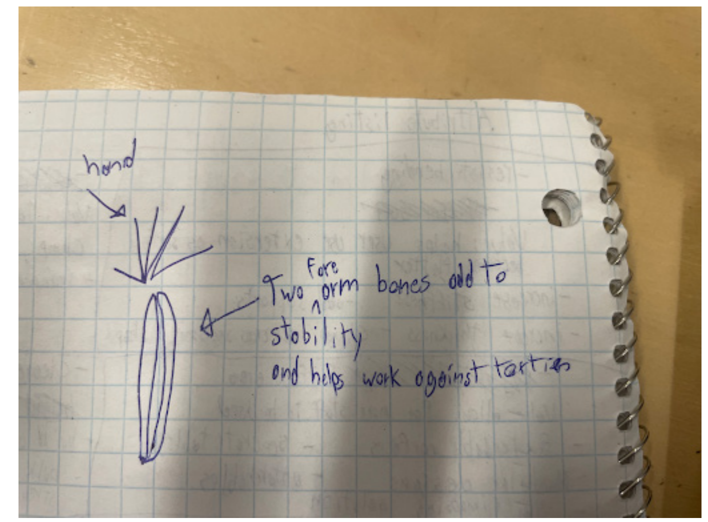


My Praxis I group organizing all the aspects of the opportunity, check the feasibility for each for the final solution
(Photo Credit: Andy Gong - EngSci 2T6)

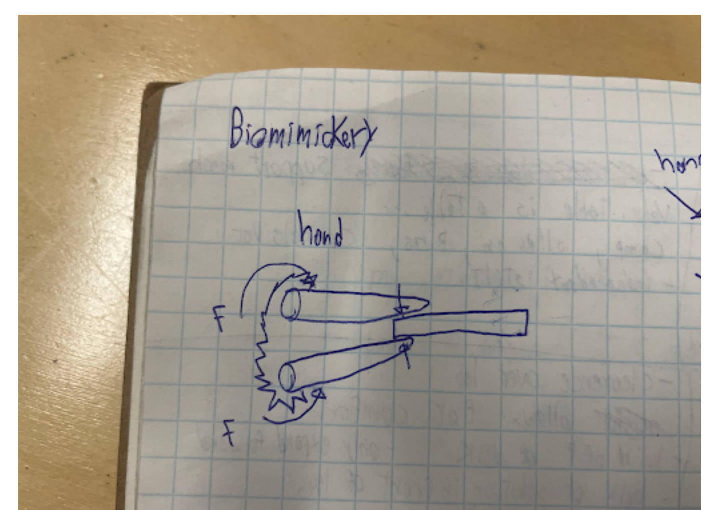
3.2 **Diverging** Techniques

The difference between diverging tools and techniques is how they solve different problems. We saw earlier how the diverging tools used different methods in order to hone in on specific aspects of a design and opportunity. Here you will learn how to use diverging techniques to generate ideas for designs.

Furthermore, it is paramount you explore and add more techniques to your engineering toolkit as the ones I will discuss may not necessarily always work for you. Play around with them and see which ones work, there is no 'right' or 'wrong' tool for the job as long as you're generating ideas.



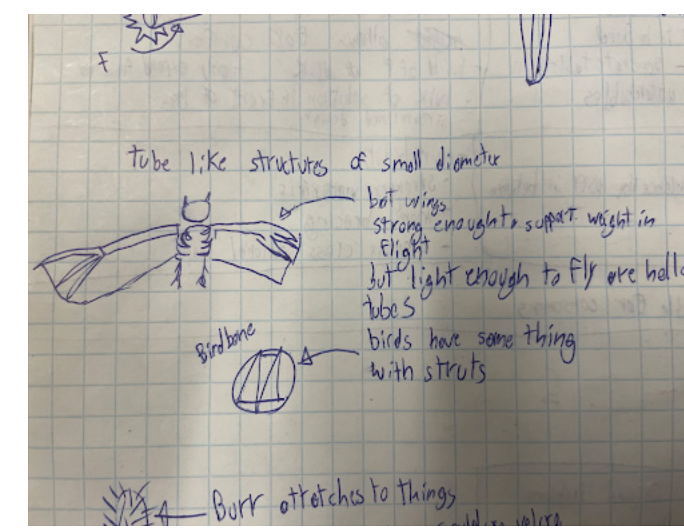
↑↓ My group's diverging process use of biomimicry from Praxis I (Credit: Michael Atkinson - EngSci 2T6)



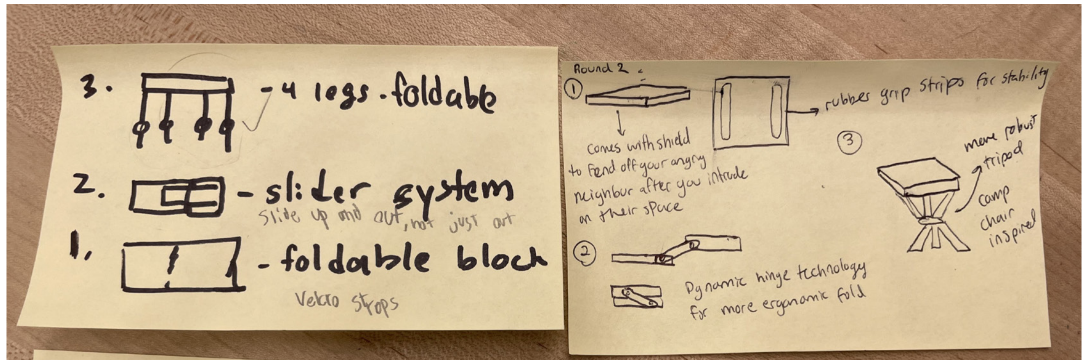
Diverging Techniques
Biomimicry

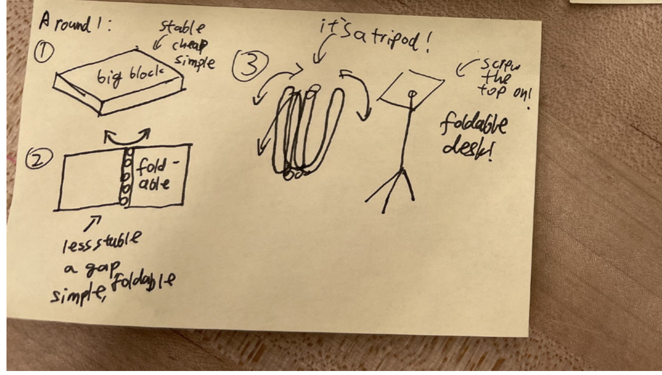
Biomimicry is the emulation of elements in nature for the purpose of solving our human problems. In engineering design, we take nature's best ideas to solve our needs. Some everyday examples include burrs and Velcro, woodpeckers and shock absorption, and insect habitats and its emulation in civil engineering.

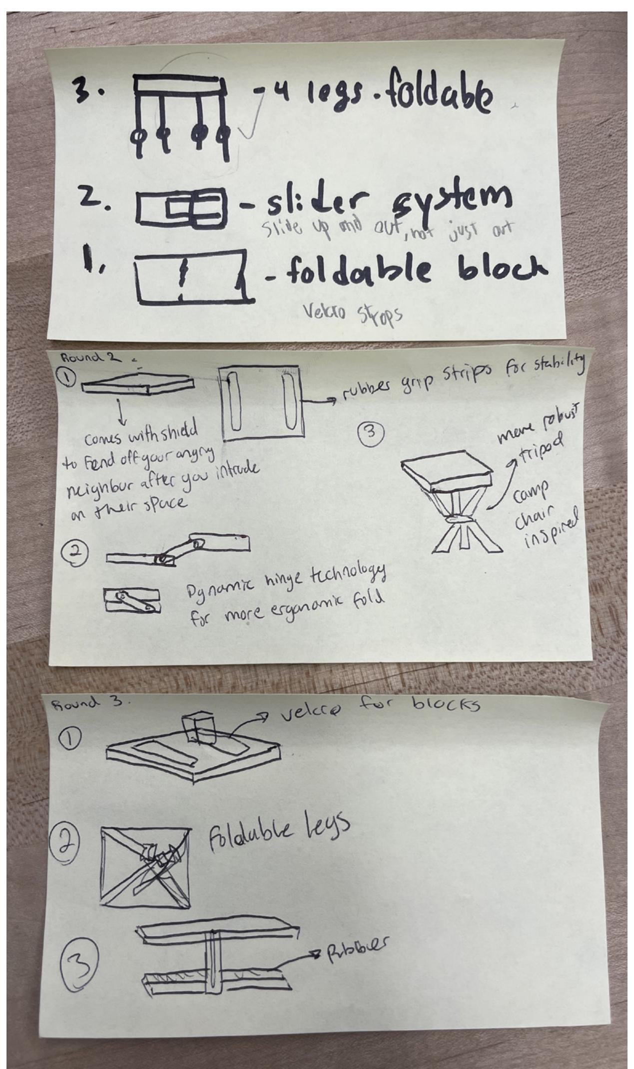
You should note however that evolution does not necessarily strive for the most optimal outcome, but rather for a solution that is less maladaptive within context of an organism's physiology. I.e. It isn't good at making things good, it's good at making things less worse. Therefore you should opt for choosing more than just biomimicry for your diverging technique toolkit.



Did you know?
Have fun with this one, you would be surprised by just how useful implements from nature can be. For all you know a giraffe's neck or a swordfish's nose could be the key to generating a good design.







Diverging Techniques
Brainwriting 6-3-5

I've got to be honest. This is my favourite diverging technique. Not for its structured and organized method of generating ideas, but because it discourages the members of the design team to conform to the opinions generated by the majority; I.e. it forces us to think independently.

The process is as follows (Usually this is done with 6 people):

0 Each member write down 3 ideas (3)

1 Pass your ideas to the next person

2 Add or modify to the ideas of the person you just got the paper from

3 Repeat 5 times (5)

By the end of the rounds you should have ideas that have been modified, added, and removed for the sake of meeting the requirements. You are literally tailoring to the opportunity.

← My group's multiple rounds of Brainwriting 6-3-5. Note the 3 designs, the eliminations of aspects, the additions, and edits

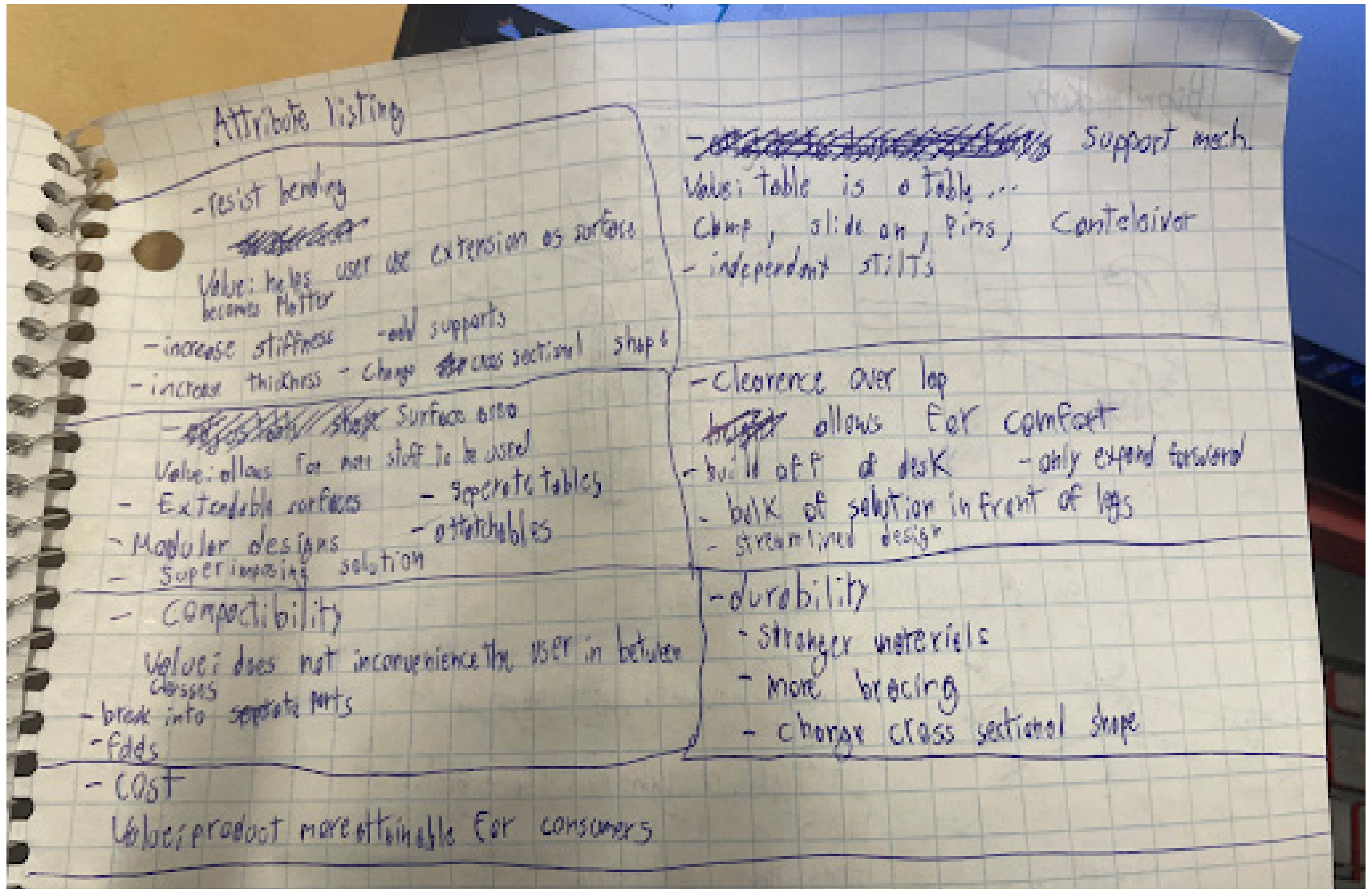
Diverging Techniques
Lotus Blossom Technique

The lotus blossom technique revolves around the process of having a central idea (which goes in the centre) and then surroundding the central idea with more related ideas or applications. Each of the outer ideas of the center square become the central idea for the surrounding squares. Your goal is to fill out as many smaller squares as possible as you generate more and more ideas and it isn't until you reach the end of the idea-generating phase that you can evaluate your ideas and gauge how they will fit with your designs.

→ Shown on the right is my group's implementation of the lotus blossom technique. Note how the center square is filled with related ideas and how the related ideas become central ideas for the surrounding squares.

Be careful of implementing this technique as you may get the rare chance that you miss the mark and your generation of ideas may be unrelated to the opportunity.

(Photo Credit: Andy Gong - EngSci 2T6)



↑ My group's process of attribute listing. Note how we were led by the objective and requirements of the opportunity.

Diverging Techniques
Attribute Listing

Attribute listing ensures all aspects of the opportunity are investigated. You break down each aspect of the opportunity down into smaller parts and list as many attributes as you can. These must be relevant to the opportunity and you must also examine the feasibility of the attribute along with having the courage to make changes in the even a certain attribute simply doesn't fit with the rest.

Questions you can ask yourself to stay in scope with the opportunity are: "How does this relate to the opportunity? What does it offer? Am I really able to implement this into my design?".

We're **evolving,**
just **backwards!**

Diverging Techniques
Reverse Brainstorming

Reverse brainstorming is the process of working backwards by reversing a problem in order to find out how it was caused in the first place. It typically follows the process of identifying ways to cause the problem then finding ways to prevent the problem from being caused.

Diverge.
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04 Converging

Convergence 4.1

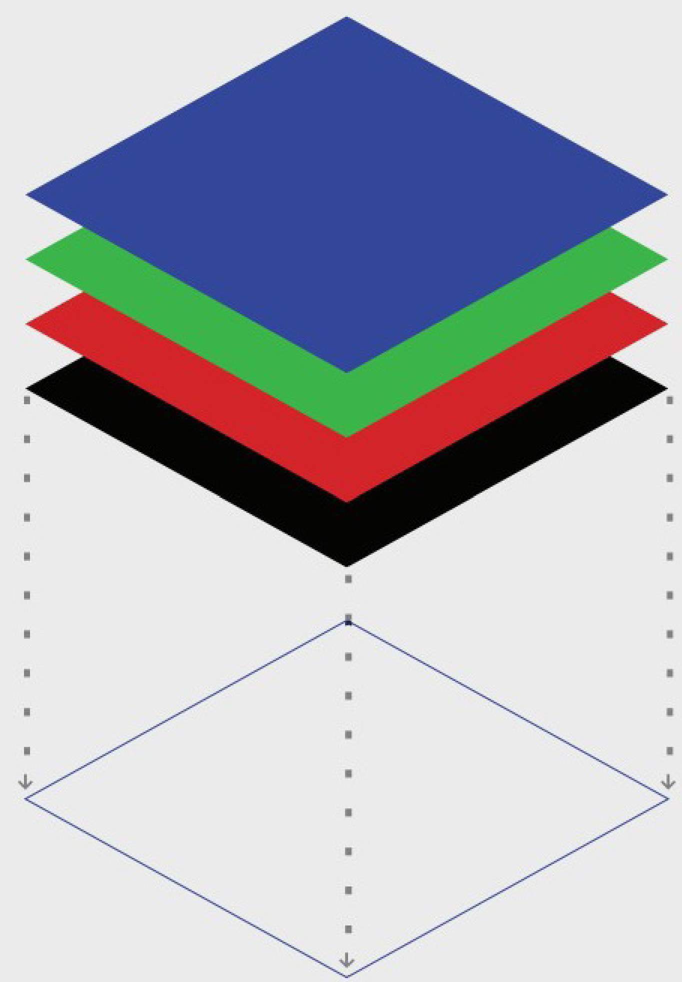
The process of converging on a solution refers to the design team narrowing the diverged list of potential solutions, basing their decisions on the requirements model. There are myriads of ways of narrowing on a design, most commonly incorporating a weighing system via the specific components of the requirements model.

Furthermore, the converging stage is critical to ensuring that the design solution is not only the most optimal, but it is feasible on the design team's end and also acceptable to the stakeholders. It is here where you will have to make the decision on which of your designs is best suited for the opportunity.

Acceptance and Acknowledgment

Convergence is a concept specific to accepting designs and acknowledging biases. This is crucial as failing to do so not only can jeopardize your task of finding a solution for the stakeholder, but it can have the potential to impose risks on the stakeholder. Designs that have been based on biased assumptions can lead to solutions that are unsafe, unethical, and inaccessible for a wide range of those impacted.

By acknowledging bias in the engineering design process, engineers can identify and address the sources of bias. This can lead to more safe and optimized designs that meet the needs not of only the stakeholders, but can also deter the chances of negative unforeseeable events.



Therefore I implore you to constantly recall the following when engaging in the design process:

0 Acknowledge your preconceived idea of “best” may not be useful to you, how it may work for another party but not directly to you

1 Elicit your biases towards your set of design concepts. Be transparent with yourself in order to minimize risk. If you have to, you can even codify them - give them metrics - to better understand the requirements

2 Gather data (measurements or research) to enable verification (to the requirements). Consult the CRAAP test. Maybe you got a certain fact wrong?

3 Systematically assess and compare your designs to determine whether they should remain, as potential design candidates.

4 Eliminate some designs if you feel they are not up to par with the requirements. Refine some designs, refine the requirements, return to Step 2 with a new set of designs to converge on

4.2 How to **converge** on a **recommended design**

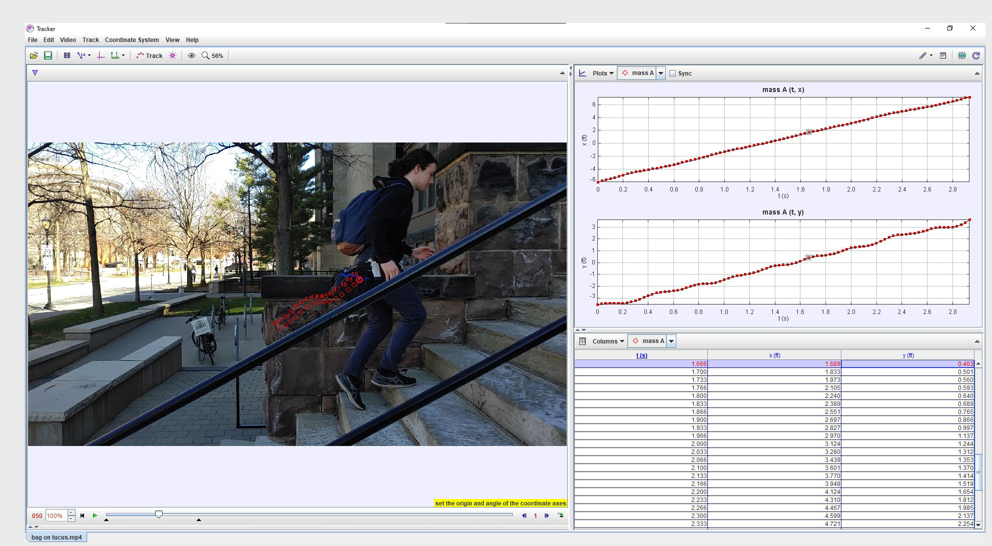
Some converging tools

The measurement matrix refers to the representation of the organized metrics as a matrix. Each row corresponds to each metric whereas each column corresponds to the design. Each entry in the matrix is usually represented with the magnitude of the metric, like a hard number. However on some occasions a metric can only be gauged via a yes or no entry as per the standards and codes it may have been subject to. Be careful when setting up the measurement matrix as usually there will always be a hard number representation available somewhere.

→ Here is the measurement matrix used for my group in Praxis I. Note how row 2.2 and row 3.1 have Yes/No entries. This come from using such tool to holistically compare the entries. (Credit: Sebastian Bradbury - EngSci 2T6)

Metrics	Drawer Design	Standalone Table Design	Fan-Folded Surface Design	Flipping Laptop Base Design
1.1 Combined area of usable flat-surface when design is in use	1587 cm^2	2100 cm^2	1598 cm^2	1250 cm^2
2.1.1 Design's dimensions when not in use	30.8 cm x 30.2 cm x 1.2 cm	40 cm x 30 cm x 4.1 cm	30.09 cm x 9.75 cm x 5 cm	32 cm x 25 cm x 2.54 cm
2.1.2 Design's mass	763 g	3400 g	620 g	1132 g
2.2 Need for tools for (dis)assembly	No	No	No	No
2.3 Cumulative time to set up and take down the design	20.42 s	90.54 s	12.09 s	15.20 s
3.1 Able to be used in SF and SS type lecture halls	Yes	Yes	Yes	Yes
3.2.1 Minimum Failure Point Load	424 N	740 N	240 N	138 N
3.2.2 Minimum failure uniformly distributed load	3.86 MPa	4.30 MPa	1.07 MPa	1.53 MPa
3.3 Maximum deflection from a horizontal surface	0.23 mm	0.3 mm	3 mm	0.016 mm
4.1 Maximum noise level during set-up, takedown, and while in-use	86.22 dB	73.69 dB	78.00 dB	90.75 dB
4.2 Per unit cost of production	$15.07	$25.29	$31.5	$8.22

Did you know?
These values are acquired from testing. Protocols can vary from design to design but usually you can find supporting documents on similar testing protocols on the web. If you can't however don't be afraid to be creative, as long as you're supporting your data with rigorous testing.



Designs	Drawer Design	Standalone Table Design	Fan-Folded Surface Design	Flipping Laptop Base Design
Drawer Design	X	Drawer Design	Drawer Design	Drawer Design
Standalone Table Design	X	X	Standalone Table Design	Flipping Laptop Base Design
Fan-Folded Surface Design	X	X	X	Flipping Laptop Base Design
Flipping Laptop Base Design	X	X	X	X

↑ Continuing from the measurement matrix, the pairwise comparison, comparing the same designs is shown. Note which design "wins"

The pairwise comparison matrix refers to the tool used to evaluate and compare multiple potential designs. Note how each design is being compared via row by column on a basis of "who wins". The winner is chosen on the basis of designating one as the "champion" and one as the "recorder". Each alternative gets a champion whose job is to argue in favor of their alternative (and against the other) and the recorder writes down only the characteristics that are raised during the argument.

→ Consultation of a pugh chart is shown. You can see the better representation of which aspect of a design is better, worse, or the same. You can also gauge which design to pick by consulting the sums on the bottom.

The pugh chart refers to the decision matrix used to evaluate multiple design alternatives based on a set of criteria, in this case the metrics. The design requirements are evaluated against each criterion and a "score" is assigned for each alternative, row by row. The scores are based on a scale on how well each design meets the requirements. After each design's row for each metric has been evaluated, the scores are tallied and the sums of the positive and negative are presented. The pugh chart allows engineers to compare each of the designs with an objective lens, focusing on quantitative data; hard numbers and facts.

Did you know?

You may run into the issue where you finished consulting the converging tools and determined a design you may not have necessarily liked. This is called 'Anchoring' and is a form of bias. Furthermore anchoring bias is closely related to the decision-making process, and occurs when one relies too heavily on either pre-existing information or the first piece of information (the anchor) when making a decision. Try your best to stay objective and stick with the results of the engineering design process.

Furthermore you may have had notions to go back to the previous stages and make changes to your data. This is completely fine such that you aren't rigging the results in favor of a certain design. Engineering design is an iterative process as your are constantly refining, re-scoping, and reframing your opportunity to fit the needs of the stakeholders. You can justify these changes with more tests, research, proxy testing, and more measurement matrices.

Metrics	Standalone Table Design	Fan-Folded Surface Design	Flipping Laptop Base Design
1.1 Combined area of usable flat-surface when design is in use	Better	Same	Worse
2.1.1 Design's dimensions when not in use	Worse	Better	Worse
2.1.2 Design's weight	Worse	Better	Worse
2.2 Need of tools for set-up and takedown	Same	Same	Same
2.3 Cumulative time to set up and take down the design	Worse	Better	Better
3.1 Ability to be used in SF and SS type lecture halls	Same	Same	Same
3.2.1 Minimum Failure Point Load	Better	Worse	Worse
3.2.2 Minimum failure uniformly distributed load	Better	Worse	Worse
3.3 Maximum deflection from a horizontal surface	Worse	Worse	Better
4.1 Maximum noise level during set-up, takedown, and while in-use	Better	Better	Worse
4.2 Per unit cost of production	Worse	Worse	Better
Sum of "better"	4	4	3
Sum of "worse"	5	4	6

05

Represent

The **Final Design** 5.1

You made it. You framed the opportunity, you diverged and generated a bountiful supply of ideas, you converged and eliminated the weakest ones, and now you finally have a solution to propose. But where do you go from here? Well you have a prototype so you might as well present your solution to the stakeholders.

Submitting a design to your stakeholders is the final step of the engineering design process. Although engineers may be eager to immediately submit their items publicly, as all things in the world, knowing the rules, regulations and standards of design submission before posting can help substantially with the approval rate.

→ Here is the final design of my group's Praxis II opportunity. It is presented as a medium fidelity prototype. (Photo Credit: Vincent Bourdé - EngSci 2T6)

A prototype is a representation that is used as the input to a measurement process to obtain a measurement of some characteristic of a design. Your prototypes are not your final "products". They are rather proof of concepts that meet the objectives of the requirements model. Furthermore they are representations of your design concepts. Prototyping enables testing via protocols mentioned before, enabling verification of your designs guided by exacting requirements.

Here are some ways to test your prototypes:

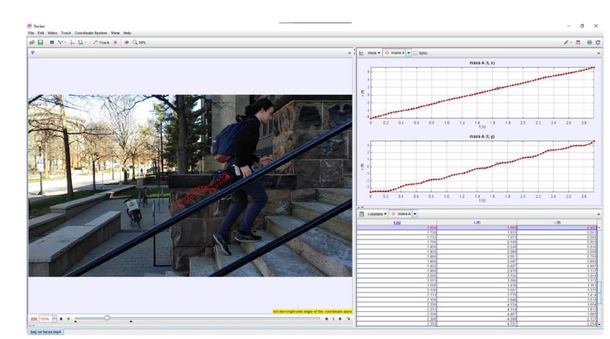
0 Determine the aspects of the design you want to assess

1 Look up standards that talk about how to run the tests. If they don't exist, then be creative and design your own

2 Develop a Proxy Test Protocol that works for the prototypes and materials you have

3 Conduct your tests and gather comparable data

Did you know?
Developing your own test protocols is normal. For Praxis II, my group had to develop our own testing protocols in order to calculate the displacement of a bag, all in order to find a metric to measure comfort.



The **Final Design**
Following Guidelines

Because your design can potentiall be a product available to the public, published and developed by a company with public relations, stakeholders will reject items that do not meet their listed guidelines. Engineers should typically in compliance with these guidelines avoid the following material:

A *Obscene material*
Designs featuring sexual content, profanity and other obscenities

B *Copyrighted material*
Designs featuring content, regardless of relative significance, not explicitly owned or created by the design team

C *National, political or religious material*
Designs featuring symbols or depictions pertaining to politics, nationality, religion, culture, tradition, ideology and society

D *Promotional material*
Designs that explicitly promote existing brands, companies, organizations or individuals

The **Final Design**
Terms of Service

In addition to following the guidelines, engineers must also accept the terms of service bestowed up them by the stakeholder. Engineers should generally:

... *not assume full control of already approved designs.*
The design team maintains copyright of the design; however, the stakeholders can use the solution as they deem fit. They may also request changes to the design after a review or prior to approval.

... *not share sales data.*
Stakeholders may require the design to keep their personal sales data confidential due to the sensitive nature of the information included. In Canada, as an employee, it is your right to talk about your aggregate earnings, however publicly discussing details on how these aggregates are calculated is disallowed without prior approval, and in general urged against

... *avoid collaborating with potentially blacklisted contributors.*
If a contributor on a design is found to be in breach of contract, the design team is also commonly liable for repairs. Consequently, engineers should avoid collaborating with individuals with a known history of copyright breach or carelessness

... *read the Terms of Service.*
This book does not feature a fully fledged synopsis on the laws and regulations between designer-stakeholder agreements. Instead, refer to the laws that applly and practice engineering design in good faith;
I.e. Use common sense

06

Resources

Citations and References

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