

Design and Innovation - CI3-

Introduction to the design of mechatronic systems

MdC. Fabio Cruz MdC Alaa Hassam

Université de Lorraine | ENSGSI

2023-02-16

Table of contents I

1 Introduction

2 The design of mechatronic systems

3 Prototyping: An overview

Introduction

Engineering and Mechanics

What is the meaning of “Engineer” for you ?

What is the meaning of “Engineer” for you ?

The word **Engineer** (Latin *Ingeniator*) is derived from the Latin words **Ingeniare** (“to contrive, devise”) and **Ingenium** (“cleverness”).

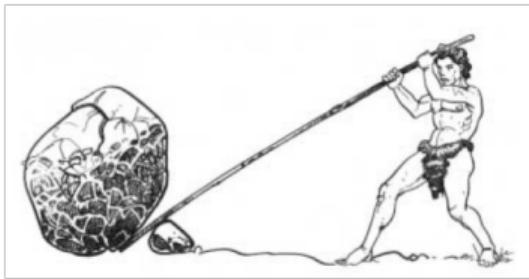


Illustration de Jean-Marie Michaud, tirée de *Aux temps anciens, les machines* de Michael et Mary Woods

© Flammarion, 2001, coll. «Castor Poche ».



What is the meaning of “Mechanics” for you ?

What is the meaning of “Mechanics” for you ?

Mathematics + Physics → Force, Matter, and Motion.

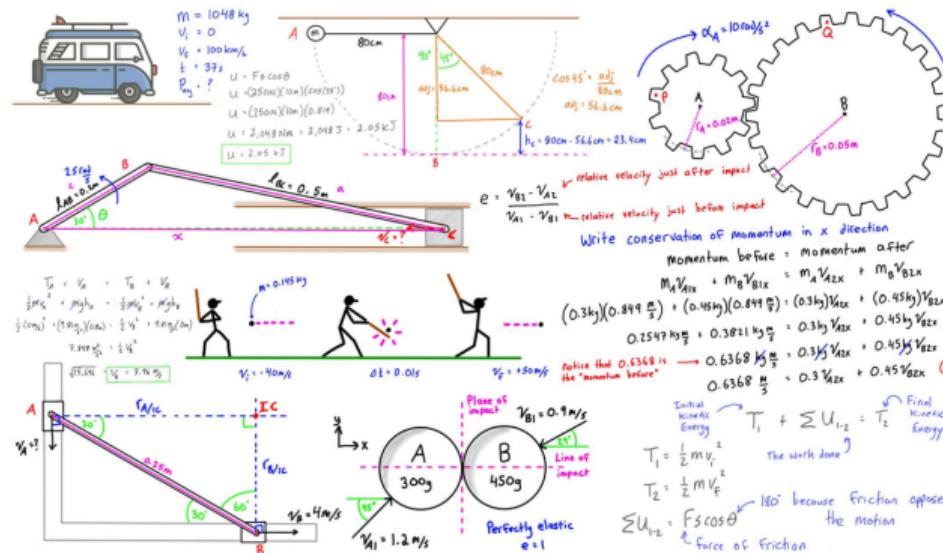


Image source: engineer4free

Challenge

Challenge

Formez des équipes de quatre/cinq personnes

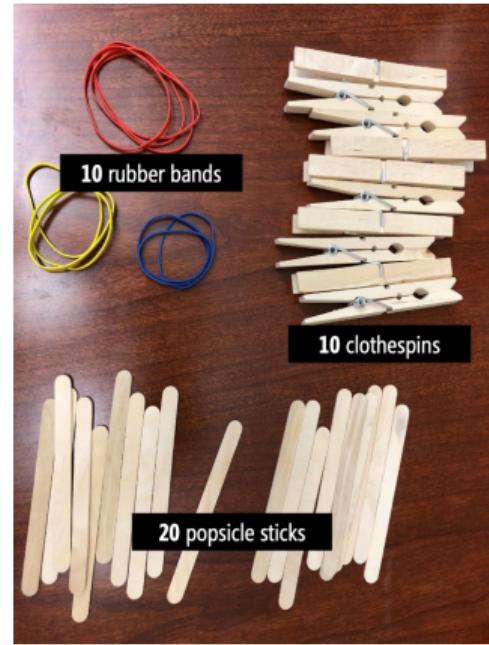
- De préférence, avec vos voisins entre les rangs.

Challenge

Vous avez 18 minutes pour construire une **tour autoprotante** qui supporte des poids calibrés avec les matériaux listés ici →

Nous noterons les tours en fonction de:

- 1 Il résiste à au moins un poids: Oui / Non
- 2 $Score = height_{weight} * weight$



18 Minutes



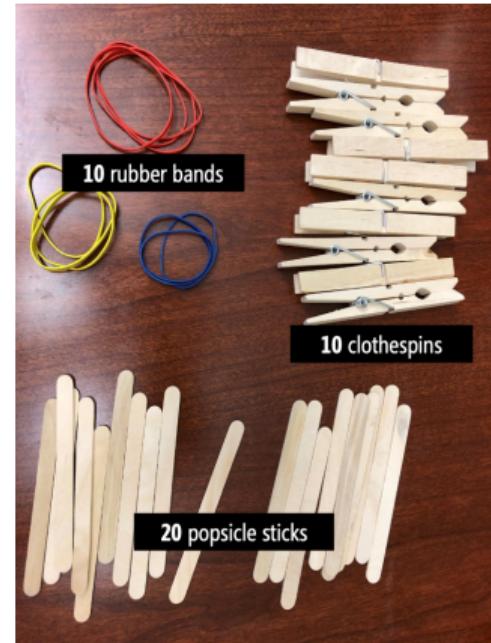
Figure 1: Timer

Timer

Reflecting on the design process

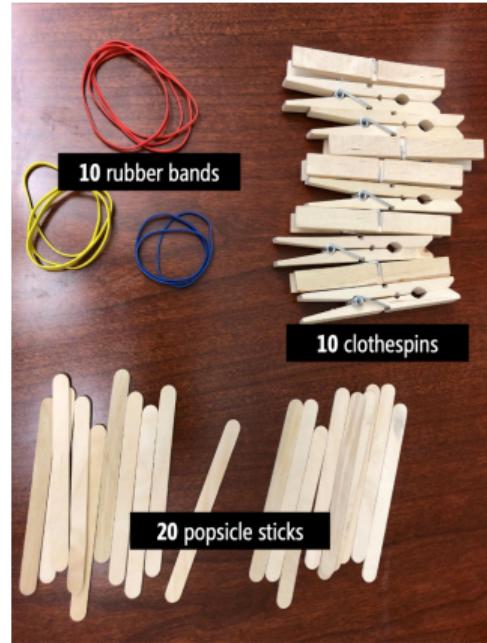
Reflecting on the design process

- What strategies did you use to make your towers?
- How many towers did you make?
- How did you learn?



Reflecting on the design process

- How many teams sketched out ideas first before starting to build?
- How many teams tried multiple ideas before settling on a final design?
- How many teams tried to use the weights during the prototyping process?
- How many teams used parts in unintentional ways (took apart clothespins)?



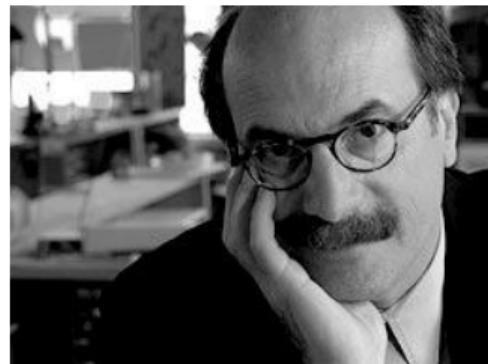
The design of mechatronic systems

Why is it important?

Why is it important for you as future Engineers in Innovation ?

Why is it important for you as future Engineers in Innovation ?

“Humans are really interesting. If you show them your idea in a prototype form, **very few people will tell you what's right about it. But everybody will tell you what's wrong with it.**”



David Kelly, IDEO

Why is it important for you as future Engineers in Innovation?

- 1 Idea → Mock-up → Proof-of-Concept → Prototype



Source : (Kattan, 2009)

Why is it important for you as future Engineers in Innovation?

- 1 Idea → Mock-up → Proof-of-Concept → Prototype
- 2 To be able to **choose the most appropriate** design tools.



Source : (Kattan, 2009)

Why is it important for you as future Engineers in Innovation?

- 1 Idea → Mock-up → Proof-of-Concept → Prototype
- 2 To be able to **choose the most appropriate** design tools.
- 3 Fail as soon as possible.



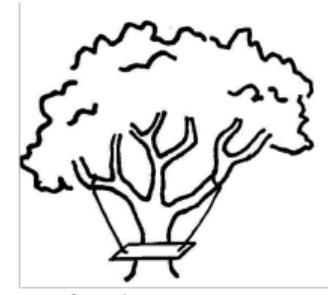
Source : (Kattan, 2009)

Fail with purpose !!

Validation of the design hypothesis



what marketing suggested...



what was manufactured...



as maintenance installed it...



what the customer wanted...

Learning goals of the module

- 1 Give you the basic skills to be able to materialize a conceptual idea into an intermediate mechatronic design object for a given concept.

Learning goals of the module

- 1 Give you the basic skills to be able to materialize a conceptual idea into an intermediate mechatronic design object for a given concept.
- 2 Learn the prototyping technologies available at the Lorraine Fab Living Lab.

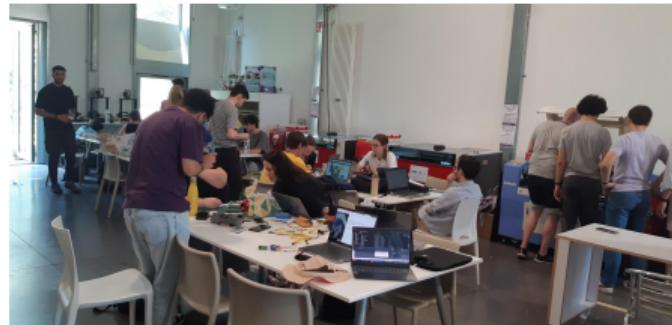
Learning goals of the module

- 1 Give you the basic skills to be able to materialize a conceptual idea into an intermediate mechatronic design object for a given concept.
- 2 Learn the prototyping technologies available at the Lorraine Fab Living Lab.
- 3 A scientific and technical baseline to independently design and build a prototype.
-Do-It-Yourself-

Specific learning goals

- 1 Prototyping phases and techniques.
- 2 Mechatronics design:
 - CAD Modeling
 - Description of a Kinematic chain
 - Control
 - Simulation of a simple movement transformation system
- 3 Fablabs and the social innovation approach.

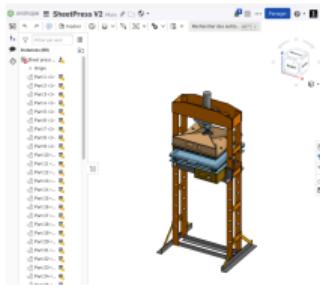
Learning by Doing !



Organization of the Module Planning

Time	Activity
7 CM	Introduction to Mechatronic Design
2 TD	Application of theory
TP 1-4	Learn Design Tools: CAD, Laser Cut, 3D Printing
TP 5-9	Projet developed by you

Technologies at LF2L.



Evaluation of the Module

- 2 tests

Individual

- Individual test (**Weight: 2/3**)

Group

- Presentation of the mechanism

Compromises

What We expect from you

What do you expect from us

Prototyping: An overview

Prototyping: An overview ?

Prototyping: An overview ?

- 1 What is Prototyping ?
- 2 What is a prototype?
- 3 Why prototype?
- 4 When to prototype?
- 5 The fidelity and dimensions of prototypes
- 6 How to prototype. The “science” of prototyping—emerging research and industry examples supporting best practices in prototyping

What is Prototyping ?

“The process of creating usable artifacts at a variety of fidelities of completion, in order to answer design questions and communicate design ideas; with users in the context of use.”

What is Prototyping ?

“The **process of creating** usable artifacts at a variety of fidelities of completion, in order to answer design questions and communicate design ideas; with users in the context of use.”



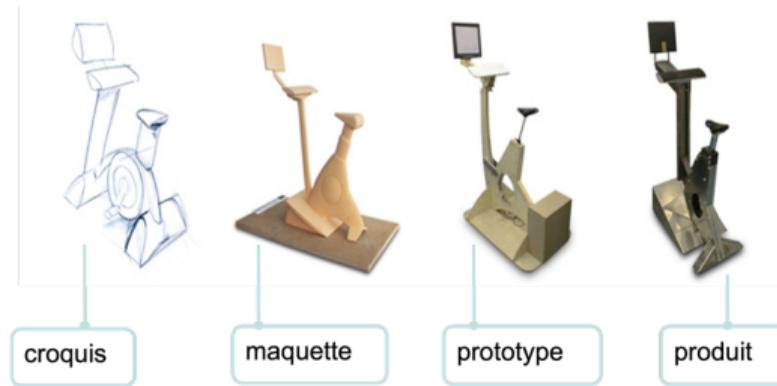
What is Prototyping ?

“The process of creating **usable artifacts** at a variety of fidelities of completion, in order to answer design questions and communicate design ideas; with users in the context of use.”



What is Prototyping ?

“The process of creating usable artifacts at a **variety of fidelities of completion**, in order to answer design questions and communicate design ideas; with users in the context of use.”



What is Prototyping ?

“The process of creating usable artifacts at a variety of fidelities of completion, **in order to answer design questions** and communicate design ideas; with users in the context of use.”

- Representation
- Precision
- Interactivity
- Evolution



What is Prototyping ?

“The process of creating usable artifacts at a variety of fidelities of completion, in order to answer design questions and **communicate design ideas**; with users in the context of use.”

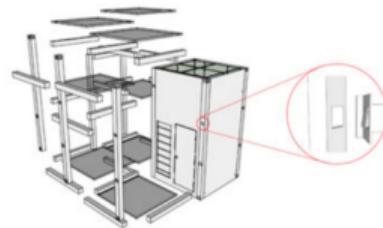


Figure 28. (Left) Usage of low-fidelity prototypes for design development of next generation refuge shelters via a series of hackathons in which many low fidelity concepts were constructed; (right) design concept informed by these low-fidelity models – a top scoring submission in IKEA's 'What Can Design Do' challenge, 2016.

What is Prototyping ?

“The process of creating usable artifacts at a variety of fidelities of completion, in order to answer design questions and communicate design ideas; **with users in the context of use.**”



Primary Users: Individuals directly using and adopting tech



Secondary Users: Not direct users, but still affected by use



Tertiary Users: sales, manufacturers, etc.



What is a Prototype?

A prototype is a tangible artifact that requires interpretation.



Interaction Design –
Simulation of Process



Industrial Design –
Form Models



Electrical Engineering –
Breadboard, Schematic



Product Design –
Simple Concept



Architect –
Model & Rendering



Creative Writing –
Storyboard Process



CompSci –
Test Code/Program



Mechanical Engineering –
Full product design

What is a Prototype?

Prototypes are designed to answer questions..

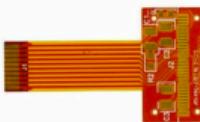
What is the general size of the device? What are some critical aspects to consider?



Can we fit all the components within the housing? Is the force of the grip appropriate?



Does this flexible PCB integrate into the device? Is the electrical-mechanical communication working?



Client comments on the length of the probe and the angle of the handle.

Team learns about handle force and angle, which then alter the next iteration.

Team finds out that there is not enough space for components, and that it is communicating.

What kind of prototype?

A prototype is a tangible artifact that requires interpretation.

- Product, Process and Service prototype



Product



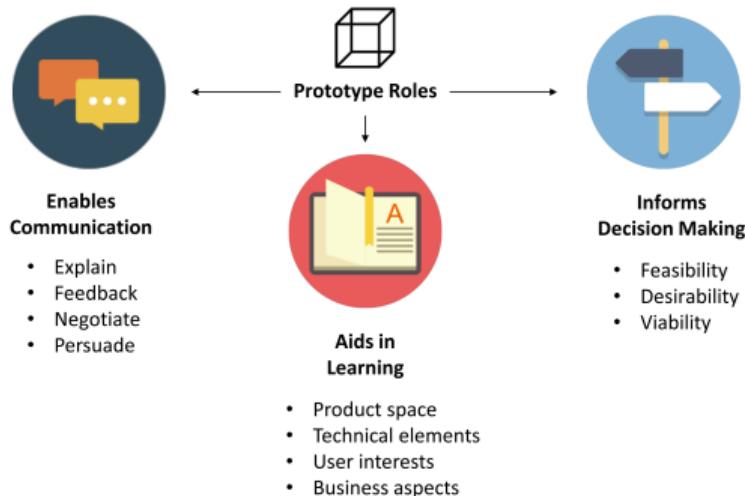
Process



Service/Experience

What role for the prototype?

Communication Aids in Learning Decision making



What benefits ?



Sony PlayStation 1 controller prototypes



Microsoft mouse prototypes

1. **Cognitive benefits:** e.g., prototypes support creativity—they help us capture and generate ideas (prototyping is generative!)
2. **Facilitate exploration of design space:** prototypes can target and manifest different attributes in a design space
3. **Permit early and iterative evaluation:** prototypes can be tested in various ways including traditional usability studies and informal user feedback, throughout design process
4. **Allow you to fail fast:** relatedly, prototypes allow you to try out and experiment with multiple ideas rapidly & fail (& learn!)
5. **Rapid prototyping:** prevents feelings attached to an idea simply because you invested effort into it
6. **To communicate:** help designers, engineers, managers, software devs, clients, and users to understand & discuss

In summary?

In summary?

Our bodies, physical actions, and use of tools and the environment shape how we think. The act of prototyping engages our bodies and senses in thought and can be faster/easier/better than mental operations alone

Next time: Information and Energy chains