‘Physics of Manufacturing’
Reverse engineering project

Projet de rétro-ingénierie
‘Objectifs pédagogiques’

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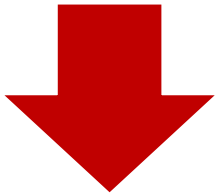
Basic principle

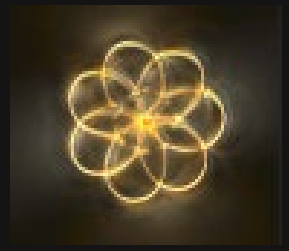
Understand how an object is made by understanding its function, by disassembling it and by identifying the individual manufacturing processes used



Learning principle based on ‘reverse engineering’

Specific learning goals

1. **Define** the object specifications (‘cahier de charges’)
2. **Translate** a functional specification into manufacturing constraints
3. **Understand** the choice of materials
4. **Critical analysis** of the manufacturing choices made
5. **Describe** the assembly process
6. **Estimate** the cost to produce this object
7. **Discuss sustainability** aspects (English course)

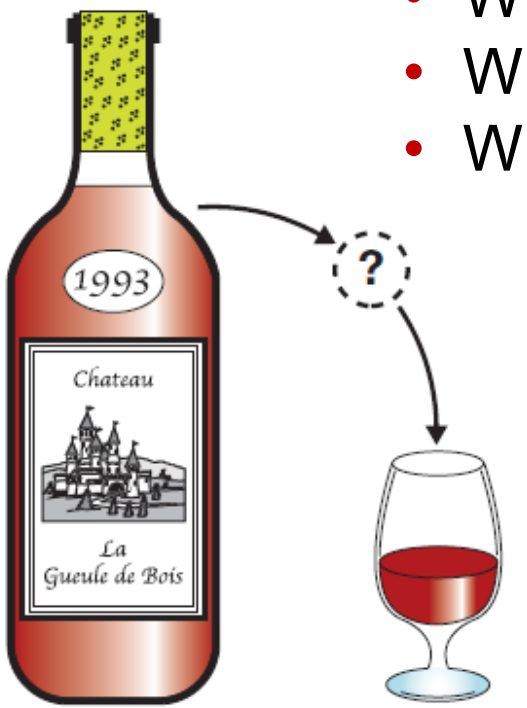


Reverse engineering methodology

Engineering problem-solving methodology: establishing requirements

Rules of the Ws

- What?
- Who?
- Why?
- Where?
- When?



Functional analysis

'What is the object suppose to do?'

'Cahier des charges fonctionnel' / Functional requirements

Ex: a manual object that can open bottles sealed with a cork, can be used outdoor or indoor, fit in a pocket, cost no more than 10 CHF, can be used by any adults (left- or right- handed), etc.

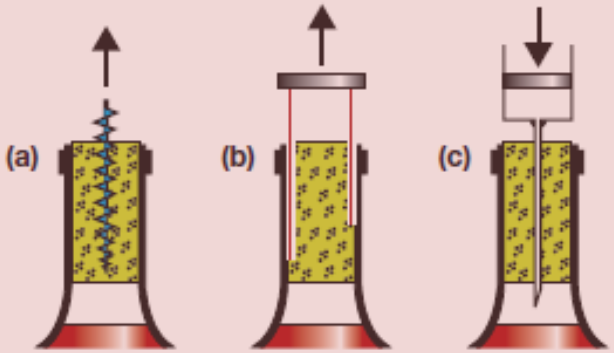
'Cahier des charges techniques' / Technical requirements

Ex: A tool that can generate a pulling pressure of xx N, ensure the integrity of the cork, occupy a volume of xx cm^3, resistant to corrosion, etc. '

Engineering problem-solving methodology

DESIGN

Find a basic working principle that fulfils the main function



(Picture A-Best, Akron, Ohio)

- Physical principle
- Establish technical requirement to fulfil the function

IMPLEMENTATION

Implement it in a practice...

- Design *Manufacturing*
- **Choices of materials**
- **Fabrication**
- **Assembly process**
- Testing

Inverse problem: '**Reverse engineering**'

- By analyzing the solution, we try to go back to the problem definition and investigate the engineering decisions that were made

Observations
Functional analysis

- *Working principle*
- *Functional requirements*
- *Technical requirements*

Technical analysis of the solution in terms of manufacturing

- Materials choices made
- Manufacturing process selected
- Assembly process implemented
- Design chosen

Evaluation of this solution:

- Where the best choices made?
- Is it sustainable? Are there alternatives?

General methodology

Feb., 28th

- **Part I /** High-level analysis

  General observations
  Functional analysis

- **Part II /** Diassembly

  Nomenclature / Taxonomy of parts
  Identifying the part function
  Relation between parts

- **Part III /** Parts analysis

  Detailed parts manufacturing analysis:
  - What materials were used?
  - What manufacturing process was used?
  - Why these choices?

- **Part IV /** Cost analysis

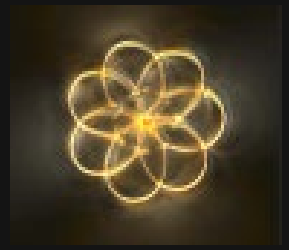
  Fabrication cost of the individual parts
  Assembly cost

- **Part V /** Critical analysis

  What are the weaknesses?
  What other principles could be used?
  Sustainability?

In class

May, 31st



Criteria for proposing an object for the ‘reverse engineering study’

Practical / Grading

- 50% of the course final mark.
- Group are done by self-enrollment. If not done, by **Feb, 22**, random assignment. **Max 3 persons per group.**
- Same mark for all group members.
- **2 hours once every two weeks.**
- **Evaluation** is based on the report.

- Finalized report is due, **June 5th 2024** on Moodle.

Object selection constraints & recommendations

1. **Motivation /** You should be interested in learning how it was made...

2. **Complexity /** It should require more than one single process to manufacture it, otherwise, you will not have much to say about it. Ideal objects are objects that uses multiple types of materials (for instance (plastics, metals, etc.), have interesting shapes, requires some assembly, etc.

3. **Practical aspects to consider /**
    1. You (or the job-shop) should be able to disassemble it easily (with reasonable tools).
    2. Portable so that it can be carried easily: you keep the object with you and bring it in class.
    3. Unfortunately, there is *no fund for buying the object*, **so you have to bring your own**...
    4. Objects do not have to be new... (or even functional as long as we can still explains and analyze how it works)

Example of objects to avoid...

- Printed circuit board, electronics,...
- Too simple (ex. clothespin)
- Single process (ex. plastic bottle)
- Too complicated because of too many small parts (ex. mechanical watch)
- Possible dangerous objects to disassemble or to manipulate (ex. pressurize canister, batteries, light-bulbs, etc.)

List of possible objects as plan B (example)

1	Puncher (Perforatrice)
2	Low-cost toaster (Grille-pain)
3	Stapler (Agrafeuse)
4	Battery less flash-light (Lampe de poche autonome)
5	Lock with number or key (cadenas)
6	Bike brake (freins de vélo)
7	Pepper mill (Moulin à poivre)
8	Umbrella (Parapluie)
9	Music box (Boîte à musique, remontage à ressort) (spring loaded only!)
10	Bike wheel (roue de vélo)
11	*Please choose for me!*

Bonus **half-point** (on the project mark) if you come up with your own idea and if it is accepted!

Frequently asked questions

- There is (unfortunately) no budget for the object…
- It can be a second-hand object.
- It may not work any more, as long as we can understand how it worked, this is fine…
- Unfortunately, we cannot store it somewhere, hence you have to take care of it…
- We will bring a set of tools at each project session to dismantle your object.
- For groups of less than 3 persons, a bonus is added to the final project mark (+0.25). The fact that only two worked on the project is also taken into account for the report evaluation.

Next step

Write a two-page proposal max. (one per team) with:

1/ Name of the students in the team / Scipers

2/ Your object proposal *(can be your proposal or one from the list)*

A. Picture of the object (does not have to be the 'actual object' that you will work on).

B. A descriptive paragraph explaining the reasons for your choice.

3/ In case your product is not selected, select your preferred object from the second-choice list ('plan B') or suggest a second-choice idea you had

4/ Upload your document on Moodle (one per group and in pdf format only).


Object proposal for the reverse engineering project

... *Deadline for object proposal: February, 25th 12.00*

Important - By Feb, 26, you must have your object with you!