Analysis and resolution of technological problems using algorithms

Authors: Pablo Rivas y María Luz Luna

Adaptation and translation: Pablo Rivas

Index

1 INTRODUCTION

Let's start remembering three concepts that we already learned last year but we will keep in mind through this course. They are: technological objects, technology and technological process or project method.

A **technological object** is any artificial object manufactured by humans to satisfy their needs and those of others.

Technology is the set of knowledge and techniques that, applied in a coordinated manner, allow humans to satisfy their needs and solve their problems, making technological objects.

The technological process or projects method is a working method we use to solve a problem or need, that consists of dividing the work in stages and gradually overcoming each, to finally solve that problem or need.

If you look at human history, we can see how man has found a way to solve different needs by (water, shelter, transportation, communications, etc.) inventing different technological objects.

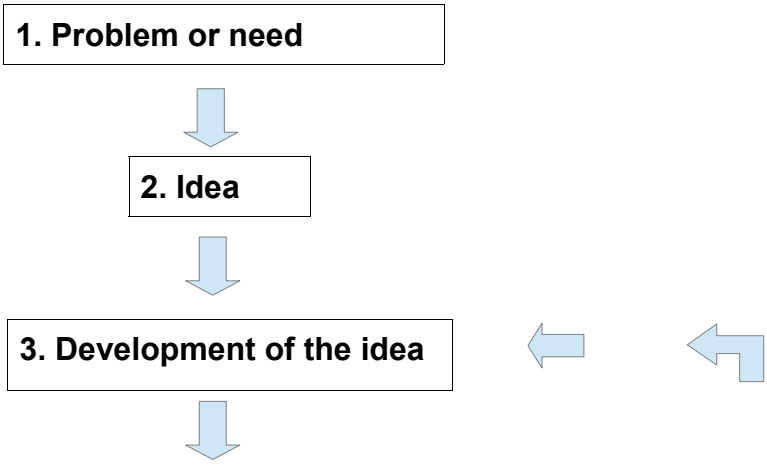
This course will also study the **analysis of technological objects and technical systems** to understand their features, elements, operating and functions they perform.

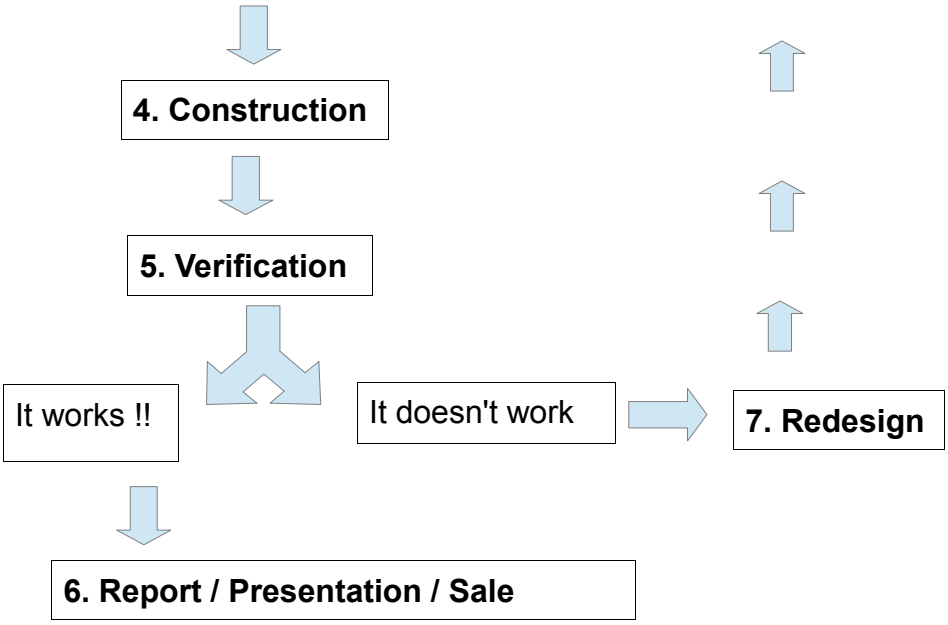
We are going to use **algorithms** to perform these activities. An algorithm is a defined, ordered and finite, set of operations, that allows us to solve a problem.

2 THE PROJECTS METHOD.

As we said before, **the technological process or projects method** is a working method we use to solve a problem or need, that consists of dividing the work in stages and gradually overcoming each, to finally solve that problem or need.

The stages of the project method are:





1. **Problem or need**: the first step is to identify what need or problem, we have to solve and to know the conditions or requirements to fulfill it.
2. **Idea**: we will see that one problem or need could have a lot of solutions. We will choose the best or the most accurate solution to solve that problem. This stage has two parts:

    - Searching for ideas: we will look for information about similar problems, to review how they have been solved and take advantage of ideas for our case. Examples: books, magazines, the Internet, shops, etc.
    - To choose the best solution: we will follow three steps:
        - Individual idea and sketch: first, each member of the the group will develop an individual idea and will draw a sketch to explain the idea to the other members.
        - Idea-sharing: we will share our ideas with the group, explaining our proposals, and we will choose the best solution for the group. We can choose an individual idea, or develop a combination of different proposals.
        - Group sketch: we will draw the sketch of our collective design.
3. **Development of the idea**: once we know how we are going to solve the problem. We have to develop our idea. To do this, we will follow two steps: design and planning.
    - Design: we will make three different types of drawings:
        - Diagram: a freehand drawing perspective, with details and measures.
        - Object views: are the drawings of the object looking from each side of it. The main views are: front view, top view or plan, and left (or right) side view.
        - Exploded drawings: the drawings of each piece with details and

measurements.

- Planning: we have to explain four elements more to have a good planning:
  - *List of materials: to choose the materials we re going to use.*
  - *List of tools: to choose the tools we are going to use.*
  - Budget: we need to know the expenses we will have in order to develop our project. Therefore, we will prepare a detailed budget of materials, tools, hours of work, etc.
  - Process sheet: we will distribute the work among the members of the group: We will detail: who will do each piece; how; the materials and the steps will be done to manufacture them.

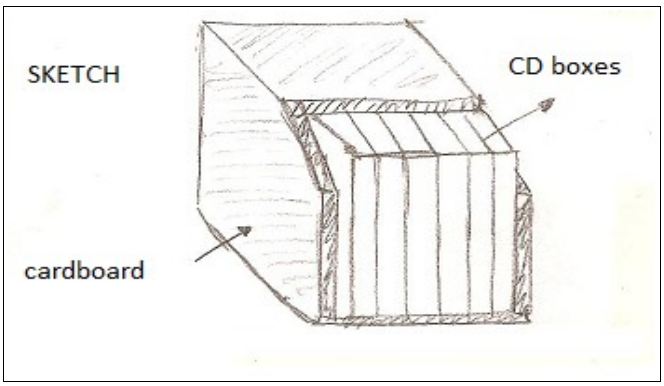
4. **Construction**: following the above steps (planning and design), we will make the parts and components of the project, according to the manufacturing techniques, safety rules and risk prevention in the workshop.
5. **Verification**: we will check the operation of the project or developed object. We will see if it works correctly and if the initial problem or need, is resolved. If all it is correct, we continue to the next stage. If not, we will return to the stage called "development of the idea", through the redesign stage.
6. **Report / Presentation / Sale**: at this stage, with the work already finished correctly, we'll show the result to our classmates. In the case of industry, this phase serves to introduce the product to customers and start selling (marketing). In both cases, we will have to prepare a report of the whole project.
7. **Redesign**: If the product is not working properly, or does not meet the needs described in the beginning, we have to evaluate errors and modify the design and planning (returning to stage 3) and from there, modify all the stages. This process will take place until our product is completely correct.

Example: Construction of a CD's storage system.

1. **Problem or need**: "Building a modular system to store CD boxes. Requirements: use cardboard, and that they can be installed over a table or a wall."

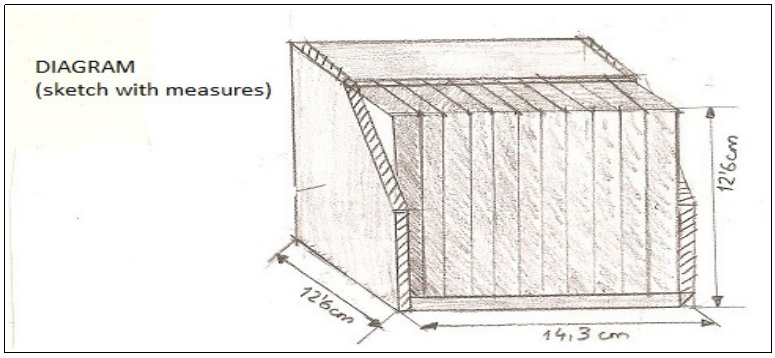
2. **Idea:**

   Searching for ideas and Individual idea and sketch.

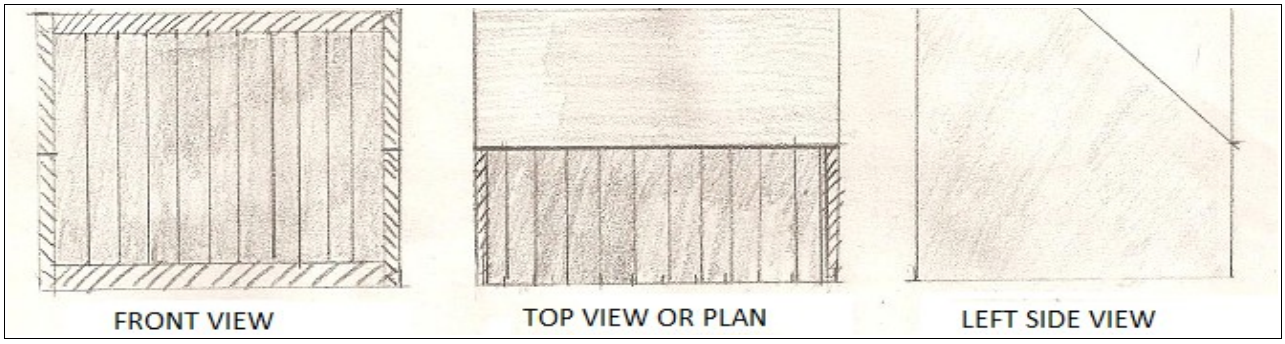


3. **Development of the idea:**

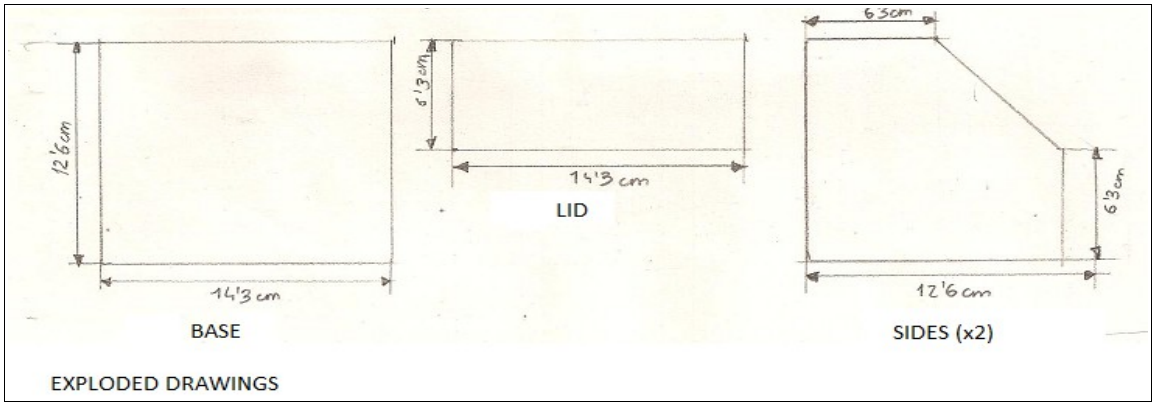
Diagram



Object views:



Exploded drawings:



3 ANALYSIS OF TECHNOLOGICAL OBJECTS

It lets us understand the operation of technological objects and makes easy further developments of the product easier. We should do the analysis from different points of view, answering the same questions for different objects. The analysis has the following steps:

1. **Formal analysis:**

   - Which shape does it have?

- What are its dimensions?
- How are the pieces assembled?

2. **Technical analysis**
   - How many pieces does it have?
   - Which materials are used to build it?
   - What other objects perform the same function?
   - What physical principles are the base of its operation?
   - What is the manufacturing process?
   - What measures have to be standardized?

3. **Functional analysis:**
   - What is it used for?
   - How does it work?
   - What are the safety risks of this object?

4. **Aesthetic analysis:**
   - How do people react to the object?
   - What is its texture, color and proportions?

5. **Socio-economic analysis**
   - What need does the object satisfy?
   - How was this need solved before the existence of this object?
   - What environmental consequences does it have?
   - How this object is sold?
   - What is its cost of manufacturing?
   - What is its price in the shops?

EXAMPLE: Analysis of a pencil sharpener.

1. **Formal analysis:**
   - Shapes: sphere, prism, pyramid, cone, etc.
   - *1,5 x 2,5 x 1 cm*
   - The blade is attached to the sharpener body by a screw

2. **Technical analysis**
   - Two parts: the body and the blade.
   - The blade: metal. The body: wood, metal or plastic.

- A blade, an electric sharpener...
- Shear (a type of stress)
- The body is manufactured by molding and the blade is made by machines for cutting and sharpening .
- Measures that allow us to use the pencil sharpener with one hand. The hole for the pencil should be standard size (about 7 mm).

3. **Functional analysis:**
   - To sharpen pencils by twisting (Torsion, other type of stress)
   - The pencil is inserted and rotated, keeping firmly attached to the sharpener
   - To cut yourself with the blade.

4. **Aesthetic analysis:**
   - Lightweight, easy to handle.
   - It has marks allowing be fastened with the fingers. Different colors or metallic. The length is greater than the width and height.

5. **Socio-economic analysis**
   - To sharpen the pencils.
   - Has a blade.
   - To throw the pencil shavings in organic trash.
   - It is sold by units.
   - It is cheaper to produce plastic than metal.
   - 1 or 2 €.

4 RESOLUTION OF TECHNOLOGICAL PROBLEMS USING ALGORITHMS

As we explained in the introduction of the unit, an algorithm is a defined, ordered and finite set of operations that allows us to solve a problem.

The projects method is also a set of ordered stages we follow to solve a problem or need. Therefore, it is very useful to use algorithms to develop a technological project following the projects method.

The algorithms can be expressed in many ways, we use two: natural language or pseudocode and flowcharts.

- First, once we identified the problem, we will use natural language to write a list of simple instructions to analyze and solve it. Also at this stage pseudocode can be used, a mixture of natural language and some commands of high level programming languages .

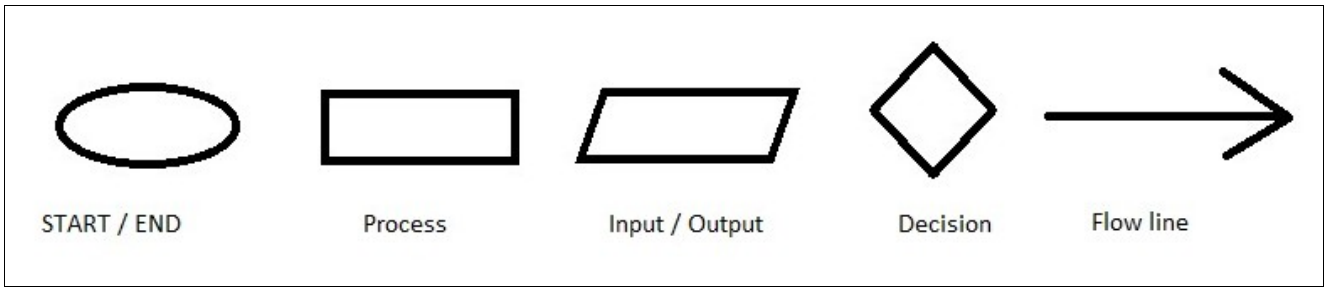
- Once we have the instructions, we will express these instructions using a graphical language of symbols and arrows, the flowcharts.

4.1 Flowcharts

They are defined as: graphic descriptions of algorithms that are made using symbols connected with arrows to indicate the sequence of instructions.

Flowcharts consist of five main elements:

- Ovals or ellipses: indicate the **start or end** of the diagram.
- Rectangles: **activity or process**, certain defined actions are performed.
- Rhomboid: **input or output** information to the system.
- Rombo: **decision**, a question is asked and depending on the answer, the flowchart follows one direction.
- Arrows: **connections** between the above elements in the flowchart.



4.2 Characteristics and types of algorithms

An algorithm must have three main characteristics:

- Ordered: indicating the order of execution of each step.
- Defined: if the algorithm is crossed several times, without any change in the conditions of the problem, the result should be the same.
- Finite: with a limited number of steps.

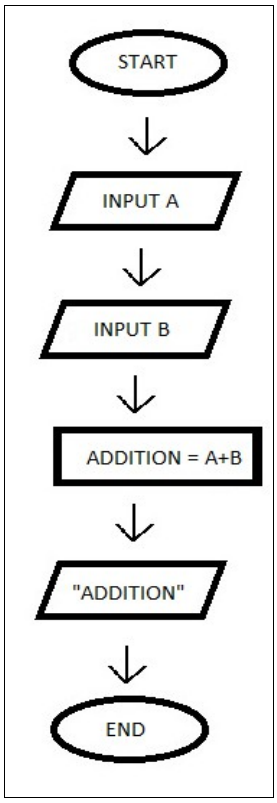
If we talk about specific algorithms of structured programming we have three types:

- Sequential algorithms: algorithms that perform an action after another, from the beginning to the end. The output of an instruction is the input of the next.
- Selective or conditional algorithms: algorithms that evaluate one or more conditions and depending on the result (decision or condition) follow one path or another.
- Iterative or repetitive algorithms: those algorithms that have a set of actions to be run more than once (Loop) in the path of the algorithm.

4.3 *Examples of algorithms*

- Sequential algorithm: addition of two numbers.

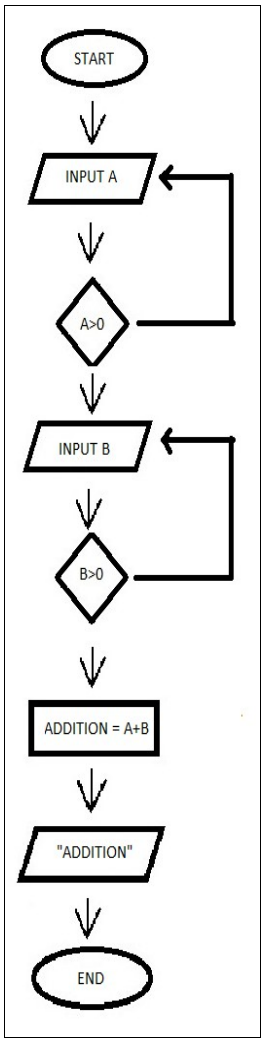
Instructions: Flowchart:



- START
- Input number A
- Input number B
- Calculate the addition (A+B)
- Show the addition in the screen
- END

- Selective algorithm: addition of two positive numbers.

Instructions: Flowchart:



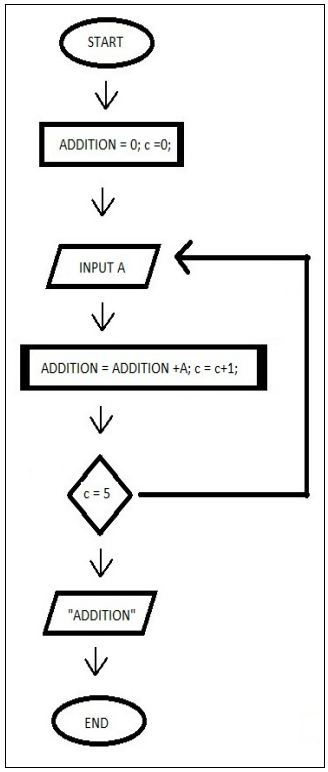
- START
- Input number A
- **Check if A is positive, if it is continue, if not back to step 2**
- Input number B
- **Check if B is positive, if it is, continue, if not , back to step 2**
- Calculate the addition (A+B)
- Show the addition in the screen
- END

- Iterative algorithm: addition of five numbers.

Instructions:

- START
- Define initial values for addition = 0 and counter = 0
- Input number A
- Add to “addition” the number A (addition = addition + A)
- Add to “counter” one unit (counter = counter + 1)
- Repeat steps 3, 4, 5 until counter = 5
- Show the addition in the screen
- END

Flowchart:



- Algorithm of the projects method: complete the flowchart , knowing the instructions.

Instructions:

- START
- Problem or need
- Idea
- Development of the idea
- Construction
- Verification; if it works continue, if not back to step 4
- Report / presentation / sale
- END

Flowchart:

5 THE WORKSHOP. THE WORKING GROUPS AND THE RULES OF HEALTH, SAFETY AND CLEANING IN THE WORKSHOP.

5.1 THE WORKSHOP

In the workshop, we develop technological projects, prototypes and scale models, following the projects method.

The workshop has three physical areas: the classroom, the workshop and the warehouse. Today we have to also include the computing classroom.

We will have four different elements distributed in the workshop:

- **Tools**, usually placed on the panels,
- **Materials**, in the warehouse,
- **Projects**, on the shelves
- **Books and manuals**, in the library of the workshop.

Tools panel

Classroom and workshop

In the workshop we work on special work tables, called **workstations**. Usually, in each one, we have a **bench vice**.

5.2 THE WORKING GROUPS

The projects are done in group or team, consisting of 4 or 5 students. The different functions are distributed among the students, changing each month or trimester. In general, the responsibilities or roles we have in the working group are:

- **Coordinator or spokesperson**: coordinates the work of the group and allocates the tasks to the members of the group. He or she represent the group in front of the teacher or other groups.
- **Secretary**: writes a report about the tasks made each day. In charge of all the written documents.
- **Tools manager**: all the tasks related to the tools (checks the tools before the beginning, fills out a tools checklist, puts the tools in the tools-panel, etc.)
- **Materials manager**: all the tasks related to the materials (asks for the materials needed for the projects, saves and recycles the materials, etc.)
- **Safety, health and cleaning manager**: makes sure that the group follows the workshop rules and the workstation is clean and tidy at the end of the class. All the group have to clean!

5.3 THE RULES OF SAFETY, HEALTH AND CLEANING

The tools we use in the workshop can be dangerous if they are not used properly. To avoid accidents of any kind, we must follow certain rules and follow the instructions of the teacher.

- **HEALTH AND CLEANING RULES:**
  - Do not eat in the workshop.
  - Hands should be clean and dry.
  - Try to have a clean desk, while working. If you will not reuse a tool, take it to your tools panel.
  - When you finish the task in the workshop, clean the workplace.
  - Save the remaining material at the end of class. You could need this material the next day.
  - Recycle non-reusable materials in the appropriate container at the end of the workshop session.
  - Be silent, noise causes irritability.
- **SAFETY RULES:**
  - It is recommended to wear the hair gathered and remove rings, pendants, etc. to prevent snagging.
  - Each task requires the use of an appropriate tool and its proper use.
  - Before using a machine or tool, be sure you know how to use it, if not ask the teacher.
  - When using machines or tools that produce shavings you must wear googles.
  - When working with heat sources (hot glue gun, soldering iron, etc.) be careful not to burn yourself or other elements (including cable). Use gloves.
  - Before drilling or manipulating a piece, make sure it is securely fastened using clamps, bar clamps or the bench vice.

- If you suffer any injury (cut, burn, etc.) ask the teacher for help.
- If a tool breaks, tell your teacher.

6 THE PROJECT REPORT.

Before the construction of a technological object, we have to complete several stages, as we have studied. This prevents errors in construction and saves resources. In this section, we will review the documents made during the stages of project method. They are what we call the project documentation or project report.

We define the project documentation or project report, as a set of documents that define what we are going to build and how we are going to do it. It consists of the following parts: memory, drawings, process sheet and budget.

1. **Memory:**

The memory is composed of a series of documents which indicate:

- The use of the object we are going to construct.
- How it is (aspect, shape...)and how to use it.
- What materials we will use and how we will build the final product.

There are three documents:

- Expositional memory: we will expose the reasons to construct this object, the use, and social purpose. Besides, we will add the discarded options, explaining the reasons why they were not selected.
- Descriptive memory: we will include external measures, shape, color, design and how the object works.
- Memory of materials and tools: we will describe the materials y tools needed for the project, the manufacturing processes and the safety use of the material and tools.

2. **Drawings:**

Drawings technically describe the object with its measures and scales.

It consists of the following drawings:

- *Diagram*: is a perspective drawing with dimensions and details. It is done freehand drawing or with rulers but with special attention to the details of the drawing.
- *Object views*: the three main views (front view, top view or plan, and left (right) side view) with measures and scales.
- *Exploded views*: the drawings of the pieces with measures and details. We have to draw all the different pieces. If there are repeated pieces , we will draw each piece only one time, adding the number of repetitions.

3. Process sheet:

It is the most important document to build, as this will be the guide to continue throughout manufacturing. It specifies each of the manufacturing stages of the project. For each stage is detailed:

- Part name.
- Materials and tools used.
- Operation (drawing, cutting, drilling, etc.) and the person in charge of the task.
- Time of each operation.

4. Budget:

It is a document that allows companies to calculate the selling price of the product manufactured with the project.

It consists of the addition of the costs of each material we use to build the project by adding the VAT and labour cots. In our case we will not include any costs for labour, but in professional projects is a very important section.

For the calculations we will make a table with the following sections:

- Number: numerical order for each material.
- Amount of each material: m, kg...
- Description: every kind of material that is purchased at a given price (we will group together all the pieces that are built with this material)
- Unit price: €/m, €/unit, €/kg...
- Total cost: amount of material x unit price.

The total cost without VAT is the addition of the costs of each material. The total cost (retail price) is equal the total cost without VAT + 21% of it.

- Example of process sheet:

Course:	Group:	Date:
Project:		Sheet n:
Piece (name, diagram...)	**Material / Tools** (Quantity)	**Operation / Person responsible**
...	...	...

- Example of budget:

Course:		Group:		Date:
Project:				Sheet n:
n	**Quantity**	**Description**	**Unit price**	**TOTAL**
...	...	...	...	...
			TOTAL without VAT	
			VAT (21%)	
			TOTAL PRICE	

7 ACTIVITIES

1. What "need" does a watch satisfy? What other objects can satisfy the same need?
2. What "need" does a bike satisfy? What other objects can satisfy the same need?
3. Think about two objects that you use every day. What uses do they have? What other objects will serve for the same purpose?
4. Explain what is technology and what is a technological object.
5. List the main stages of the project method and explain them.
6. Write some of the rules of health and cleaning to be followed in the workshop.
7. Write some of the rules of safety to be followed in the workshop.
8. Technology has three workspaces: the classroom, workshop and computer room. Explain what we do in each.
9. Name the main roles to be performed by members of a working group in the workshop and explains each one.
10. Complete the analysis of the following technological objects:
    - Pen
    - Broom
    - Clock
11. Explain why we have to make the process sheet and the budget of the project.

12. Develop the following examples of algorithms (instructions and flowchart):

- Multiply 5 positive numbers and show the result.
- "Check the class list" (if the student is in the classroom, continue to the next student; if not, mark the absence and continue to the next)
- Calculate your average mark for the subject of technology, programming and robotics. If it is equal to or greater than 5 display the message: "PASS, ... congratulations !!" and if it is less than 5, "FAIL, ... Don't give up!!".

13. Complete the following example of budget:

N	Quantity	Material	Unit price	Total price
1	1 piece of 0,20 x 0,30 m	Board of plywood of 4 mm of thickness and measures 2,44 x 1,22 m 2,44 x 1,22 m	25,50 €/ board (48 pieces for each board)	____ €
2	250 mL	Glue	_____ €/tin of 1 L	4 €
3	_____	Cardboard	1 €/m^2	6 €
4	150 cm	cellophane	0,10 €/1 m	_____
5	12	Sticks of plastic	____ €/unit	1,2 €
			Total (without VAT)	_____€
			VAT: (21%)	_____€
			TOTAL PRICE	_____€