

# FEMSTEAM MYSTERIES: STEAM SCENARIO TEMPLATE

## Title

*Are electric scooters sustainable?*

## Autores

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## Summary

*Electric scooters have disrupted urban mobility in cities. They are presented as ideal means of travel for short journeys and sell an image of sustainable transport. But is this really the case? In this scenario, students are asked to argue if electric scooters are sustainable from the study of electricity bills, lithium batteries, the relationship speed, time and cost of the electric scooter; the sustainability of the materials with which electric scooters are built, the financing of the purchase of electric scooters, the use of the scooter as an alternative transport to come to school, the optimization of the way to come to school and the robotization of the collection route of electric scooters for rent, the recognition of how computing and robotics is at the service of society to solve problems that it faces. From the reflection on the life of Eleni Stroli playing with the game FemSTEAM Mysteries, students are asked to reflect on the need of equalitarian opportunities for men and women studying, working and researching in STEAM professions. Finally, students are asked to design the graphical environment of an electric scooter, which would help to transmit the idea of sustainability of the Earth.*

## Matters

- The physics subject should allow students to analyze and study the relationships between speed, time and cost of using the electric scooter and the modifications in electricity bills due to its use.
- In the subject of chemistry, students study lithium batteries and their alternative in the use of magnesium batteries.
- The study of the materials used in the construction of electric scooters and their sustainability will be carried out in the field of technology and digitalization.
- In the subject of mathematics, students will study the financing processes of electric scooters for purchase, the route of school roads to come to it and its optimization for use with electric scooters, and the statistical analysis of how the use of electric scooters can affect the health of those who use them.
- The robotization of the collection route of the electric scooters for rent will be carried out in the field of Computing and Robotics.
- The artistic design of the electric scooters will provide a background to understand, design and implement 3D isometric and cavalier perspectives.

## Real-life questions

The real-life questions that students must answer arise from the main question "Are electric scooters sustainable?", and are:

- How do I change my electricity bill by using an electric scooter?
- Are lithium batteries sustainable? What would happen if we used magnesium batteries?
- What is the relationship between the cost, speed and time of using the electric scooter?
- Are the materials used in the construction of an electric scooter sustainable?
- How should the route of an Mbot-robot collecting the rental electric scooters be designed, implemented and purged?
- How does computing help find solutions to everyday problems? What information does the game "FemSTEAM Mysteries" give you about it?

- What graphic design of an electric scooter elicits the vision of sustainability?
- How can we ensure that the purchase of an electric scooter meets the highest quality requirements?
- What are the optimal school routes to come to school on an electric scooter?
- How can the massive use of electric scooters affect health?

## Scenario objectives

Scenario objectives:

- *Develop a responsible attitude based on the awareness of the degradation of the environment based on the knowledge of the causes that cause, aggravate or improve them, from a systemic vision, both local and global.*
- *Identify the different aspects related to responsible consumption, assessing their repercussions on the individual and common good, critically judging needs and excesses and exercising social control against the violation of their rights.*
- *Develop sustainable lifestyles based on the understanding of the functioning of the organism and critical reflection on the internal and external factors that affect it, assuming personal and social responsibility in self-care and the care of other people, as well as the promotion of public health.*
- *Cooperate and coexist in open and changing societies, valuing personal gender equality and cultural diversity, as a source of wealth and being interested in other languages and cultures.*
- *Develop the skills that allow you to continue learning throughout life, from confidence in knowledge as an engine of development and critical assessment of the risks and benefits of the latter.*

## Connection with STEAM networks

Students will develop, in particular, a critical and creative thinking about the sustainability of electric scooters, and in general, will favor the development of a transdisciplinary vision of STEAM studies and careers consisting of:

- *The use of inductive and deductive methods typical of mathematical reasoning in known situations and the selection and use of different strategies to solve problems by critically analyzing the solutions and reformulating the procedure, if necessary.*
- *The use of scientific thinking to understand and explain the phenomena that occur around them, relying on knowledge as an engine of development, asking questions and testing hypotheses through experimentation and inquiry, using appropriate tools and instruments.*
- *The approach and development of projects designing, manufacturing and evaluating different prototypes or models that generate or use products that solve a need or problem creatively and as a team, seeking the participation of the entire group, peacefully resolving conflicts that may arise, adapting to uncertainty and valuing the importance of sustainability.*
- *The interpretation and transmission of the most relevant elements of processes, reasoning, demonstrations, methods and scientific, mathematical and technological results in a clear and precise way and in different formats (graphs, tables, diagrams, formulas, schemes, symbols ...), and taking critical advantage of digital culture and including mathematical-formal language, with ethics and responsibility to share and build new knowledge.*
- *The undertaking of scientifically based actions to promote physical, mental and social health, and preserve the environment and living beings; and apply principles of ethics and safety in the realization of projects to transform their immediate environment in a sustainable way, valuing their global impact and practicing responsible consumption.*

## Age of students

1 4-15 years

## Tiempo

**Preparation time: 1 hour**

**Teachingtime:**

- **Preparation: 1 hour**
- **STEAM Physics: 1 hour**
- **STEAM Chemistry: 3 hours**
- **STEAMMa themes: 4 hours**
- **STEAM Art: 5 hoursra**
- **STEAM Technology and digitalization: 2 hours**
- **STEAM Computing and Robotics: 10 hours**

**Assessment time: 1 hour**



## Teaching resources (material & technological tools)

### **Materials:**

Design materials: Drawing instruments, watercolors, pin celes, black marker  
 Physics, chemistry and technology laboratory materials: balance, dynamometer, tape measure, pH meters, laser meter, distilled water, alcohol, lugol reagent, Benedict reagent, Fehelin, Sudan III, Biuret reagent, Sodium hydrogen carbonate, Absorbent paper, paper filters, virgin wax, magnesium in tape, syringes, beakers, settling funnel, washing bottle, racks, bottle replacements, washer bottle, spatulas, 500 ml plastic specimens  
 Computer materials and robotics: computer, Makebloc 2 mBot Ranger Robot (one for each team of students).

### **Online tools:**

*FemSTEAM Mysteries game*

*Geogebra*

*Arduino*

## 21<sup>st</sup> century skills

This educational scenario will develop the following key competences:

- The cooperative work will help to increase linguistic competence in communication since students must interact orally and in writing coherently with different purposes: present their beliefs about why computing is at the service of society and how it can be exercised by both men and women equally, prepare a manual on what questions they must ask to ensure a purchase and financing of an electric scooter that has the highest quality requirements.
- The mathematical competence will be developed by analyzing solutions of a problem using different techniques and tools, evaluating the answers obtained, to verify their validity and suitability from a mathematical point of view and their global impact on the other STEAM subjects.
- The scientific, technological and engineering competence will be increased through the study of physical, chemical and technological models that allow to know the sustainability of electric scooters and the application of computing methods so that the MBoot2 can travel the indicated path to collect the electric scooters for rent.
- Digital competence will be developed through the use of Internet search engines, using the criteria of quality, timeliness and trust by selecting the results critically. In addition, the development of digitization competence by learning about STEAM reference models in FemSTEAM Mysteries gamification and the use of software such as Geogebra for graphical representation and Scratch for programming.
- In relation to civic competence, students will increase their critical thinking, their understanding and analysis of the current problems faced by STEAM students. In addition, they will value how the study of them is a contribution to the creation of an egalitarian society.
- The competence of the sense of initiative will develop at the same time as creative thinking increases when they design the Mboot robot and design the graphics of the electric scooter to make it sustainable. This design will also allow the development of competence, awareness and expression. The entrepreneurial competence will be developed at the same time as increasing the creative thinking when designing their mboot roboy and the design of the

## Teaching approaches and learning strategies/theories

The main methodology to be applied is a problem-based learning that arises when wanting to answer the main question, "are electric scooters sustainable?" and the secondary questions found in the questions section for real life.

To answer the questions "how should the route of an Mbot2 robot collecting the electric scooters for rent be designed, implemented and evaluated?" and "What graphic design of an electric scooter raises the vision of sustainability?", students will apply the methodology based on the design of engineering and artistic products.

In addition, cooperative learning will be applied as a basic work methodology as a tool that must allow students to establish their objectives, resolution strategies, implementation and evaluation.

## Educational scenario

Activity Name	Processo	Time
Lesson 1: Project motivation		
Brainstorming and discussion	Are electricscooters sustainable? <ul style="list-style-type: none"><li>Comprehensive reading of newspaper article <a href="https://theconversation.com/son-sostenibles-los-patinetes-electricos-148592">https://theconversation.com/son-sostenibles-los-patinetes-electricos-148592</a></li></ul>	60' Annex I
Discussion for the preparation of the first lesson	<ul style="list-style-type: none"><li>Analysis of the advantages and disadvantages of the electric scooter</li></ul>	35' Annex I
Lesson 2: Playing with FemSTEAM Mystery game		
Any STEAM subject	<ul style="list-style-type: none"><li>Understanding Eleni Strouli's contributions to computation for society welfare. FemSTEAM Mysteries game: <a href="http://femsteam-project.eu/">http://femsteam-project.eu/</a></li></ul>	60' Annex II
Learning Products	Creation of the questions to ask Elena Strouli on how to improve the sustainability of cities.	
Lesson 3: Is the electricity bill changedby the factof using an electric scooter?		
STEAM Physics	Is the electricity bill changed by using an electric scooter? <ul style="list-style-type: none"><li>Search for bills from different electricity companies from different periods in different weather stations.</li><li>Location of different items on the invoice</li><li>Complete a table with the main indicators of an invoice</li><li>Analysis of the parameters that vary according to the different electricity companies and date of consumption.</li><li>Analysis of how the electricity bill would vary depending on the need to charge one or more electric scooters daily.</li></ul>	60' Annex III
Learning Products	Essay on howthe electricity bill is modified by using an electric scooter.	
Lesson 4: Are lithium batteries sustainable? What would happen if we used magnesium batteries?		
STEAM Chemistry	Are lithium batteries sustainable? What would happen if we used magnesium batteries? <ul style="list-style-type: none"><li>Reading on the sustainability of lithium batteries</li><li>Analysis of the environmental hazard of lithium batteries in the laboratory</li></ul>	3 h Annex IV



Activity Name	Processo	Time
	<ul style="list-style-type: none"><li>● Analysis of the measures to toamr in the use of lithium batteries.</li><li>● Reflection on what would happen if we left lithium batteries out in the open</li><li>● Reading an article about magnesium batteries</li><li>● Analysis of the reaction of magnesium with chloridric acid</li><li>● Theoretical resolution of the reaction of magnesium with oxygen</li><li>● Reading an article about magnesium and water</li><li>● Analysis of the effects of leaving magnesium batteries out in the open</li></ul>	
Learning Product	<i>Laboratory memory of the lithium and magnesium experience</i> <i>Essay on why magnesium batteries shouldbe used instead of lithium batteries to build electric scooters.</i>	
Lesson 5: Are the materials used in the construction of an electric scooter sustainable?		
STEAM Technology and digitalization	<ul style="list-style-type: none"><li>● Search on the history ofelectric scooters</li><li>● Parts of an electric scooter</li><li>● Analysis of the demand for the utility of an electric scooter</li><li>● Comparison of models on demand</li><li>● Analysis of the environmental impact of electric scooters</li></ul>	2 h Annex V
Learning Product	<i>Classification table of thesustainability of the construction materials of an electric scooter</i>	
Lesson 6: How to ensure that the purchase of an electric scooter meets the highest reliability requirements?		
STEAM Arts	<ul style="list-style-type: none"><li>● Comprehensive reading of informationon electric scooters</li><li>● Application in the determination of the variables that affect the price</li><li>● Analysis of the veracity or falsity of discounts and percentage changes</li><li>● Application in the calculation of the absolute and relative error made when approximating the percentage</li><li>● Comprehensive reading of the variables that affect financial mathematics and the determination of consumer loans</li><li>● Analysis of a newspaper advertisement</li><li>● Applying financial knowledge to solving contextualized problems</li><li>● Analysis of the characteristics of the increases in payment frequencies</li></ul>	3h Annex VI
Learning Product	<i>Manual on what information should be sought on the Internet, ask a seller and the bank for financing to ensure that the purchase of the electric scooter has the highest quality requirements.</i>	



Activity Name	Processo	Time
Lesson 7: What route should I travel if I want to go to school with my electric scooter?		
STEAM Mathematics	<ul style="list-style-type: none"><li>Comprehensive reading of the rules of the National Directorate of Traffic on Road Safety and the electric scooter.</li><li>Analysis of the route drawn in google maps and assessment of whether it complies with the rules of the National Directorate Traffic on Road Safety.</li><li>Comprehensive reading of the meaning of Taxi-distance</li><li>Application of numerical and spatial sense learning in understanding the meaning of taxi-distance</li></ul>	1 h Annex VII
Learning Product	Solving the problem of calculating the taxi distance to go from home to school	
Lesson 8: What is the minimum and maximum estimated time to go to school from home using an electric scooter?		
STEAM Physics	<ul style="list-style-type: none"><li>Reminder of the kinetic model of uniform motion. Equations</li><li>Application of formulas in the calculation of minimum time, maximum time and estimated speed</li><li>Analysis of the graphical representation of space-time functions for two scooters to evaluate these models</li><li>Application of the knowledge developed in the representation of functional graphs that describe the space/time relationship to go to school from home</li></ul>	1 hour Annex VIII
Learning Product	Graph describing the space/time relationship to go to school from home	
Lesson 9: How can the massive use of electric scooters affect health?		
STEAM Math	<ul style="list-style-type: none"><li>Analysis of statistical tables and graphs</li><li>Health impact assessment</li></ul>	1 hour Annex IX
Learning Product	Creation of a 200-word essay that answers the question: what are the effects of the electric scooter on health?	
Lesson 10: How should the route of an Mbot-robot collecting rental electric scooters be designed, implemented and purged?		
STEAM Computation and robotics	<ul style="list-style-type: none"><li>Analysis of the different components of the mBoot 2 robot</li><li>Programming in mBlock</li><li>Create a sequence of movements so that the robot describes a trajectory that goes from Colegio La Salle-Buen Consejo to the Centro Administrativo de Puerto Real on an A3 scale map and undo the path.</li></ul>	10 hours Annex X
Learning Product	Programming code of the route of collection of the scooters with the mBot2 in the School to reach the Administrative Center of Puerto Real	
Lesson 10: What graphic design of an electric scooter elicits the vision of sustainability?		
STEAM	Reflective answer to questions:	5 boras



Activity Name	Process	Time
Plastic and visual education	What message do I want to convey with the graphic design of the electric scooter? How can my message be translated into visual elements that convey the sustainability of the planet? Design and painting of the 3D elements of the scooter	
Learning Product	<i>Final design of the 3D elements of the electric scooter</i>	

## Evaluation

### Initial assessment

*Brainstorming whether electric scooters are sustainable*

### Formative assessment

- *Laboratory memory of the lithium and magnesium experience*
- *Creation of the questions to ask Elena Strouli on how to improve the sustainability of cities.*
- *Essay on why magnesium batteries should be used instead of lithium batteries to build electric scooters.*
- *Essay on how the electricity bill is modified by using an electric scooter.*
- *Classification table of the sustainability of the construction materials of an electric scooter*
- *Solving the distance taxi problem*
- *Graphic describing the space-time relationship to go from home to school on a scooter*
- *Programming code of the collection route of electric scooters with the mBot2 in the College to reach the Administrative Center of Puerto Real*
- *Creation of a 200-word essay that answers the question: what are the effects of the electric scooter on health?*
- *Final design of the 3D elements of the electric scooter*
- *Manual on what information should be sought on the Internet, ask a seller and the bank for financing to ensure that the purchase of the electric scooter has the highest quality requirements.*

### Final evaluation

- *Answer to the question: "Are electric scooters sustainable?"*
- *Reflection on the role of women in the design of electric scooters to improve the sustainability of the Earth*

### Student feedback

### Feedback from teachers



## Annexes

Annex I: Motivation: Are electric scooters sustainable?

Annexo II: Playing with FemSTEAM Mysteries game

Annexesor III: How is the electricity turnover changed by using an electric scooter?

Annexor IV: Are lithium batteries sustainable? What would happen if we used magnesium batteries?

Annex V: Are the materials used in the construction of an electric scooter sustainable?

Annex V: How to ensure that the purchase of an electric scooter meets the highest quality requirements?

Annex VII: What route should I travel to go to school with an electric scooter?

Annex VIII: What is the minimum and maximum estimated time to go to school from home using an electric scooter?

Annex IX: What are the effects of the electric scooter on health?

Annex X: How should the route of an Mbot-robot collecting electric scooters for hire be designed, implemented and purged?

## ANNEX I: ARE ELECTRIC SCOOTERS SUSTAINABLE?

### 1. Do a comprehensive reading of the following newspaper article:

Se presentan como medios de desplazamiento idóneos para trayectos cortos y venden una imagen de transporte sostenible. Pero ¿lo son realmente?

 **THE CONVERSATION**  
3 noviembre, 2020

  4

Electric scooters have disrupted urban mobility in cities. They are presented as ideal means of travel for short journeys and sell an image of sustainable transport. But are they really?

To answer this question, we must analyze the environmental impact throughout its life cycle, from the moment in which the materials are obtained to manufacture them until they end up as waste in a landfill.

### Why they are not currently sustainable

The first research that has evaluated the sustainability of electric scooters based on life cycle analysis is recent. They have considered an American city, Raleigh (2019), and a European city, Brussels (2020).

Studies agree on their conclusions: electric scooters for hire emit more greenhouse gases during their life cycle than the means of transport they replace. That is, they do not contribute to reducing pollution globally.

The way of getting around that users would have used if they had not had an electric scooter at their disposal were, in this order: walking or cycling, going by car and going by public transport.

The short service life of electric scooters for rent means that the relative impact of the manufacturing and extraction process of materials (such as aluminum for the frame or lithium for batteries) in the emission of pollutants is very high. It accounts for more than half of emissions.

### How could its environmental impact be reduced?

Fortunately, the useful life of scooters has been increasing since the first models appeared, so it is expected that their sustainability will improve in the coming years.

In addition to betting on recycled materials with less environmental impact, the researchers propose that batteries continue to be optimized and designs improved to make them more resistant and durable.

The administrations could also help by establishing measures to prevent vandalism, as well as enabling a network of lanes with the appropriate pavement through which they can circulate safely.

If an electric scooter of those analyzed in Brussels lasted more than 9 and a half months, it would already emit fewer pollutants than the means of transport it replaces. And if it reached an average life of 5 years, its environmental impact would drop by 70%.



The second cause of emission of polluting gases from electric scooters for rent is related to the system of collection and recharging of batteries of scooters.

A study published by the German University of Bochum proposes some measures that could help reduce the environmental impact in this phase. For example, use detachable batteries instead of fixed ones, so that you do not have to transport the entire scooter to recharge it, or use electric vehicles instead of diesel for battery collection.

## Scooters for personal use, more sustainable

The Brussels study states that electric scooters for personal use pollute half as much as electric scooters for hire, mainly due to the following reasons:

1. The life of the scooter for personal use is longer thanks to more responsible use and being less exposed to vandalism.
2. It does not require any vehicle to pick them up to recharge the batteries and distribute them through the parking lots.
3. Owners of electric scooters replace to a greater extent more polluting modes of transport, such as the car, than users of electric scooters for hire.

## Bicycles are much less polluting

According to data published by Weiss and collaborators, the impact on global warming of bicycles during their life cycle is 25 times less than that of electric scooters for hire. And that of electric bikes is two and a half times less than that of electric scooters for personal use.

In short: if we are looking for a sustainable means of transport, bicycles, including electric ones, have a lot of advantage over electric scooters. In addition, the environmental impact of rental bikes is lower than that of the modes of transport they replace, according to an article published in the journal Sustainability.

These data suggest that investments in urban mobility made by public administrations should bet on bicycles. However, as indicated by the survey published by New Zealanders Angela Curl and Helen Fitt, it should be borne in mind that the segment of the population that uses the electric scooter seems to be wider than that which uses the bicycle, so they could be complementary means of transport.

In addition to pollution, there are other factors related to electric scooters that will condition their future development, as some studies show. These include safety and coexistence with other road users, especially pedestrians.

Another important factor that has not yet received sufficient attention is the long-term health effects of reduced physical activity for electric scooter users. They replace many trips that were previously made actively, walking or cycling. In short, electric scooters are not currently sustainable in all scenarios. But they have the potential to become efficient means of transport that contribute to



reducing the impact on global warming of urban mobility, especially when they replace more polluting means of transport, such as the car. Studies such as those discussed here can help make appropriate decisions to achieve this.

\* *Article originally published in [The Conversation](#).*

*Authorship: [Iván López-Fernández](#).*

*[Professor Faculty of Education Sciences, University of Malaga](#)*

0. Use the rotating folio technique to indicate what are the advantages and disadvantages of electric scooters. Summarize in the following table the advantages and disadvantages of using an electric scooter:

Advantages	Disadvantages

1. Use the rotating folio technique to indicate what aspects we need to investigate to reach the conclusion on whether or not electric scooters are sustainable. Analyze in which subjects you should perform each of these analyses.

## ANNEX II: PLAYING WITH FEM STEAM MYSTERIES GAME

2. Enter room number 3 of the game FemSTEAM Mysteries and investigate if Eleni Strouli would be an example of an international reference that could provide a solution to mobility in cities.

Accessing the game with Microsoft computers: <http://femsteam-project.eu/>

Access the game with MAC computers from the App and search for FemSTEAM Mysteries.

3. Explain with the pencil technique to the center what research problem you would pose to Eleni Strouli to improve the sustainability of transport in cities, in general, and the use of electric scooters, in particular.

## ANNEX III: HOW IS THE ELECTRICITY BILL MODIFIED BY USING AN ELECTRIC SCOOTER?

1. Look for bills from the electricity company you have at home from different periods, different weather stations.
2. Locate the following items on the invoice:
  - Holder and NIF of the Holder
  - Supply address
  - Type of contract
  - Counter type
  - Access toll
  - Contracted power
  - End date of the contract
  - Invoice issue date
  - CUPS Unified Supply Point Code
  - Free customer service telephone and complaints from the marketer
  - Free telephone number for breakdowns and emergencies of the distributor
  - Contact to make possible claims.
3. Complete the following chart for the different team members.

What is the invoiced date?	What power do you have contracted?	Price for contracted power	What is the consumption in the billing period?	How much does the kWh cost per month?	Final price of the receipt

4. Analyze in the different bills which are the parameters that vary according to the date of consumption.
5. Analyze which company offers better prices according to the following parameters:
  - a. By contracted power

- b. Per Kw/h consumed according to time discrimination (valley and peak) or stable rate.
6. It concludes as a team on:
  - a. How does it affect electricity consumption according to the period of the year in which we are?
  - b. How would the use of an electric scooter affect the electricity bill?
7. Write individually an essay that answers the research question: how do you change the electricity bill by using an electric scooter?



## ANNEX IV: ARE LITHIUM BATTERIES SUSTAINABLE? WHAT WOULD HAPPEN IF WE USED MAGNESIUM BATTERIES?

1. Shared reading of the article:

<https://www.sacyr.com/-/hasta-el-nobel-y-mas-alla-retos-de-las-baterias-de-litio-pa-ra-un-futuro-sostenible>

2. The National Institute of Safety and Hygiene at Work indicates that the alkaline metallic elements of group 1 of the periodic table in contact with water cause the rapid decomposition of this to combine vigorously with the anion (OH) and creating the corresponding stable hydroxides and releasing hydrogen, a "very exothermic" reaction. Its speed and violence will depend, in addition to the "temperature of the water", on the "degree of subdivision of the solid": "If the element is chopped or particulated, the contact surface with the water is much greater, increasing the danger.

Study this danger in the laboratory. To do this,

- Use a discharged lithium battery. Open it and extract the lithium itself (Help yourself from the video: <https://www.youtube.com/watch?v=ydCfLFJqaBw>)
- Check what happens when wet with water with different temperatures.
- Check what happens when you chop it up and wet it.

3. Analyze the following infographic from Iberdrola and explain why they make these recommendations for the use of lithium batteries:



4. What would happen if we left lithium batteries out in the open?

5. Read the following article about magnesium batteries and explain why they are viable:

<https://www.hibridosyelectricos.com/articulo/tecnologia/baterias-magnesio-cobre-electrolito/20200525182740035395.html>

6. Analyze the reaction of magnesium with hydrochloric acid. To do this:

- Pour HCl into a tube and add the indicator (see figure). Add the magnesium tape and observe and note the changes that occur:
  - "Effervescence" occurs. Bubbles are observed coming out of magnesium.
  - The color of the indicator becomes paler.

- The tube is heated.
- "Smoke" comes out of the solution.
- Magnesium becomes shiny.

7. Explain what was observed:

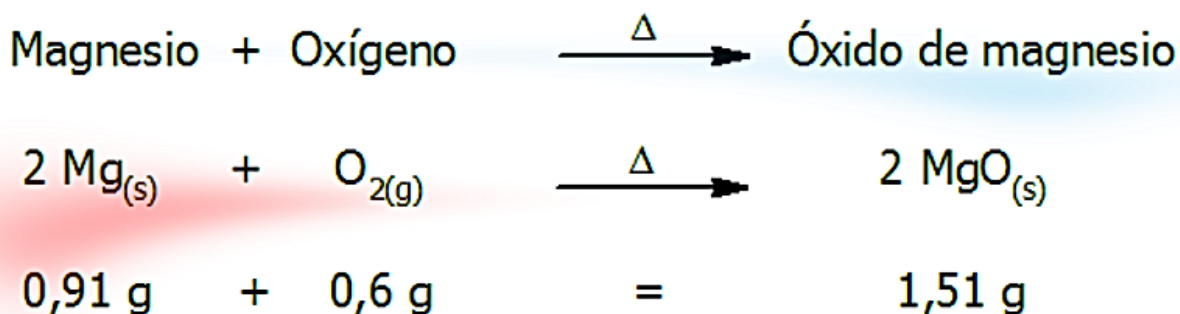
- The effervescence is due to the hydrogen (gas) that is released in the reaction.
- The fact that the indicator becomes paler indicates that the acid is consumed in the reaction.
- The fact that the tube heats up tells us that we are facing an exothermic reaction.
- "Smoke" is small droplets of water carried away by hydrogen. When the light hits them it scatters giving that whitish color ("smoke")
- Magnesium becomes shiny because the acid dissolves the oxide layer.

8. Resolves the following issue:

Problem B: A 0.91 g magnesium tape burned in a closed container containing 3.6 g of oxygen. After the reaction it was found that 3 g of oxygen remained unreacted. What mass of oxygen did not react? How much magnesium oxide was formed?

Reasoning: The mass of which it reacted is obtained by difference between the initial and final mass, since both are known. Then, knowing the mass of oxygen that reacted, it is added with that of magnesium to obtain the mass of magnesium oxide formed.

- Resolution: Reacting oxygen mass = 3.6 g - 3.0 g = 0.6 g
- Mass of MgO formed = 0.91 g of Magnesium + 0.6 g of oxygen = 1.51 g



Answer: 1.51 g of magnesium oxide was formed.

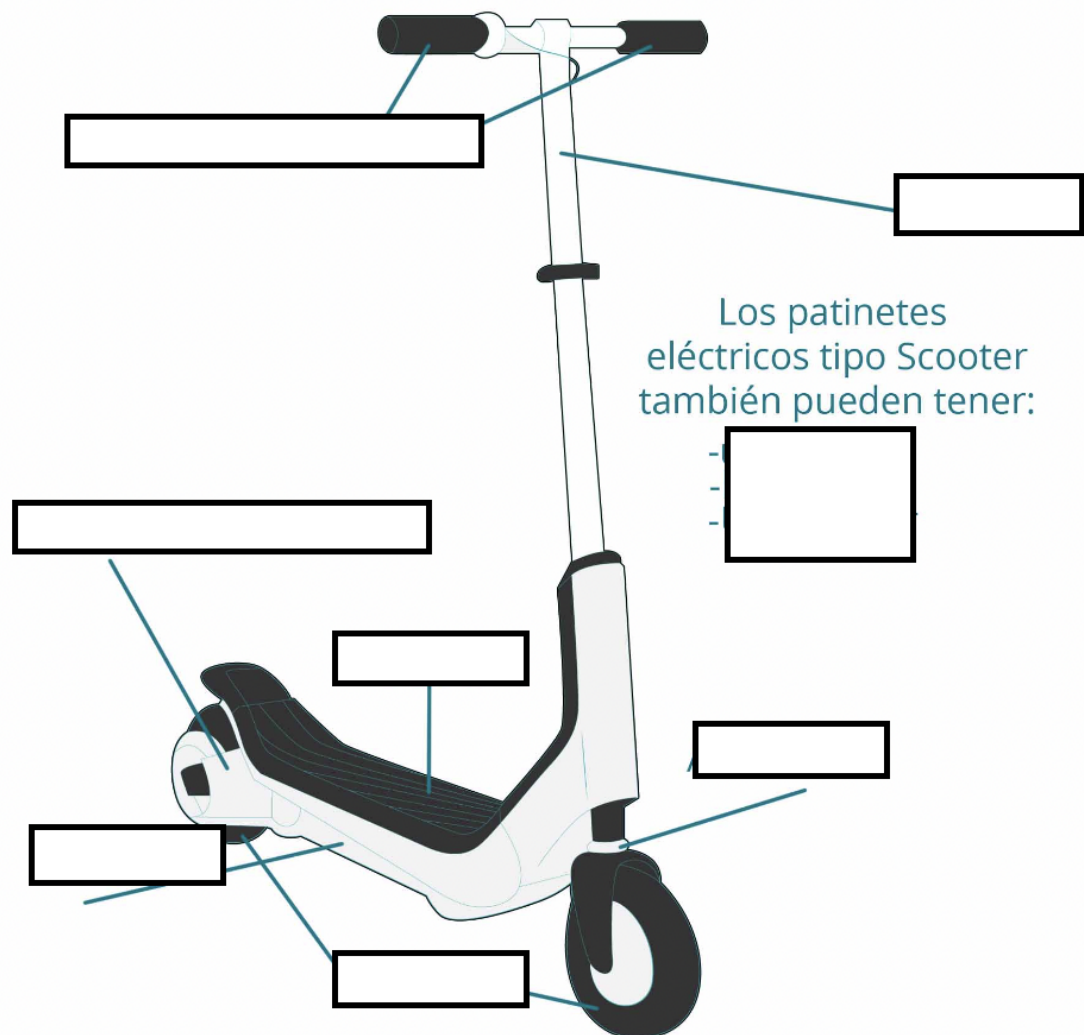


9. Read the following article on magnesium and water: reaction mechanisms, environmental impact and health effects:  
<https://www.lenntech.es/magnesio-y-agua.htm#:~:text=Cuando%20este%20compuesto%20se%20pone,t%C3%B3xico%20y%20tambi%C3%A9n%20muy%20inflamable>.
10. Would magnesium batteries left out in the open have the same effects?
11. Write an essay on why current lithium batteries in electric scooters should be replaced by magnesium batteries



## ANNEX V: ARE THE MATERIALS USED IN THE CONSTRUCTION OF AN ELECTRIC SCOOTER SUSTAINABLE?

1. Conduct an Internet search on the history of electric scooters as a technological product.
2. Search the Internet for information about the parts that an electric scooter has and write them down in the following infographic:



3. Think about what you would demand from an electric scooter to make it useful to come to school daily and classify them according to Basic demands (B), functional demands (F), exciting demands (A)
  - a. Easily clean

- b. That the color is not lost
- c. Comfortable handlebar grip
- d. Make the base wide
- e. Make it look attractive
- f. That vibrates little
- g. Make no noise
- h. Have a good braking
- i. Smooth acceleration, jerkless
- j. That the height is adjustable
- k. That the handlebar does not twist
- l. Have good cushioning
- m. That the wheels do not slide
- n. Make it stable
- o. Requires little maintenance
- p. Foldable
- q. That you can hang the helmet
- r. That the goat's leg is stable
- s. That does not lose power when there is low battery
- t. That it has autonomy
- u. Load fast
- v. That can be located
- w. Count the miles
- x. That it has a certain height so as not to touch the bass
- y. That the wheels can be locked
- z. Make it lightweight

4. Compare these two models of electric scooter and indicate which ones meet the basic and functional demands that you have considered that electric scooters should have:



### E-motion Advance



Ilustración 18. Patinete E-motion Advance

- **Peso:** 16 kg.
- **Material:** aluminio
- **Tamaño neumático:** 8"
- **Dimensiones:** (1100x300x1200) mm.
- **Velocidad máxima:** 32km/h.
- **Potencia:** 350W.
- **Autonomía:** 23,4 km.
- **Capacidad batería:** 8800 mAh.
- **Tiempo de carga:** 4,45 horas
- **Carga máxima:** 120 kg.
- **Luces:** LED
- **Suspensión:** Doble delantera
- **Frenos:** Tambor
- **Precio:** 450€

### Cecotec Outsider E-volution



Ilustración 19. Cecotec Outsider E-volution

- **Peso:** 13 kg.
- **Material:** aluminio
- **Tamaño neumático:** tubeless 8,5"
- **Dimensiones:** (1080x424x1140) mm.
- **Velocidad máxima:** 25km/h.
- **Potencia:** 350W.
- **Autonomía:** 25 km.
- **Capacidad batería:** 6400 mAh.
- **Tiempo de carga:** 3 – 4 horas
- **Carga máxima:** 120 kg.
- **Luces:** LED
- **Suspensión:** No
- **Frenos:** Disco, trasero
- **Precio:** 300€

5. Complete the following table that analyzes the materials needed for the production of an electric scooter unit and indicates its sustainability and the process of recyclable, toxic, biodegradable or renewable

Piece	Materials	Recyclable, toxic, biodegradable or renewable	Sustainable
Engine			
Battery			
Loader			
Base			
Hinge			
Wheels			
Suspense			
Mud guard			
Tires			
Headlamp			
Hook			
Digital doorbell			
Handlebar			
Brake lever			
Brake disc			
Brake cable			
Brake pad			
Digital display			
GPS			
Velocimetro			
Electric cable			

6. Analyze the following graph and compare the sustainability of electric scooters with respect to other means of transport.

**Impactos ambientales de patinetes eléctricos**  
en comparación con otros modos de transporte | Co<sub>2</sub> en g/km

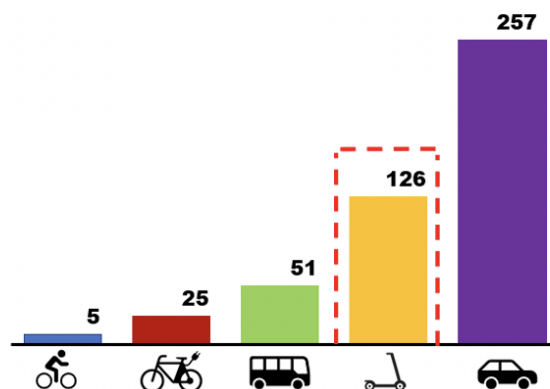


Gráfico 6: Impactos ambientales de patinetes eléctricos en comparación con otros modos de transporte.

Fuente: Elaboración propia en base a (Hollingsworth et al., 2019) y (Stalinsky, 2019)

## ANNEX V: HOW TO ENSURE THAT THE PURCHASE OF AN ELECTRIC SCOOTER MEETS THE HIGHEST QUALITY REQUIREMENTS?

The article mentions that *"if an electric scooter of those analyzed in Brussels lasted more than 9 and a half months, it would already emit fewer pollutants than the means of transport it replaces. And if it reached an average life of 5 years, its environmental impact would drop by 70%."* That makes us wonder if all electric scooters have a five-year durability capacity. In this case, what would be the cost of purchasing it for its half-life to be so long? On the contrary, if it lasted 9 and a half months, what should be the maximum price of the scooter to be profitable? With the following activities we will focus on answering the previous questions analyzing, among others, the relationship between the price, the fees, the time and the frequency of payment of these installments.

1. Access the following website and read the information carefully  
<https://www.accesoriospatineteelectrico.com/precios-patinetes-electricos/>
0. With the rotating folio technique, indicate which are the variables that affect the price of an electric scooter.
0. In the announcement of the following electric scooter, it indicates that the discount is 15%.

**Patinete eléctrico Bongo**  
**Serie A. Potencia máxima de**  
**700 W, Batería**  
**Intercambiable, autonomía**  
**ilimitada hasta 25 km,**  
**Ruedas Tubeless**  
**antirreventón de 8,5", 3**  
**Modos de conducción**

Patinete eléctrico adulto

Sin Stock

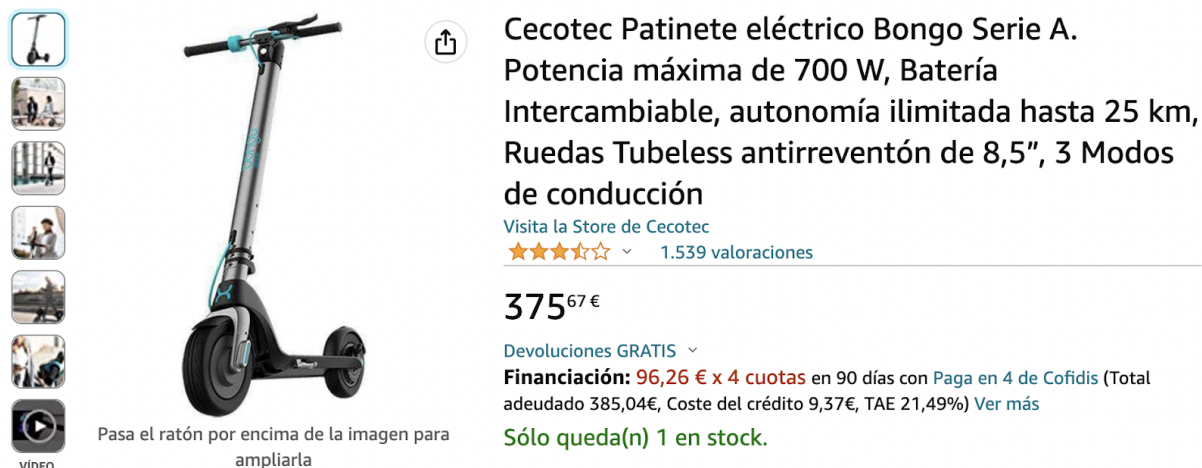
Descripción | Composición

**299,00 €** IVA incluido

~~352,00 €~~ (-15%)

- a. Reason whether it is true or false that the percentage of the discount is exactly equal to 15%. What would be the rate of change of the discount in this case (Remember  $iv=1-\%/100$ )
- a. What would be the real value of the reduced scooter if exactly 15% were applied?
  - a. What is the absolute mistake made when rounding up the actual discounted value by the value indicated in the € 299.00 ad?
- a. What do you think is the reason for the seller rounding incorrectly?
0. In the following announcement of the installment sale of an electric scooter they indicate the results of the financing.





Pasa el ratón por encima de la imagen para ampliarla

- a. Indicates from the shared reading of the ad:
1. What is the initial price (capital)?
  2. What is the final price after financing?
  3. What is the cost of the credit?
  4. How many days do you have to pay?
  5. How many fees do you have to pay?
  6. What is the APR they apply to us?

In short:

$C_0$ : initial capital (€)

$C_f$ : final capital (€)

$R$ : Revenue (%)

$T$ : Time (years)

$f$ : frequency of payment of instalments

APR: Annual percentage rate (%)

The formula of the APR known the revenue (as much as 1) and the frequency of payment of the installments:

$$TAE = 1 + rff - 1$$

The compound interest formula at a yield (in %) and time expressed in years.

$$C_f = C_0(1 + r)^{100t}$$

The formula of simple interest to a return (in %) and time expressed in years is:

$$C_f = C_0(1 + r \cdot t100)$$

0. Using the pencil technique in the center, analyze the following ad:

Deportes y aire libre › Deportes › Movilidad urbana › Patinetes y equipación › Patinetes › Patinetes eléctricos



**Patinete Electrico - hasta 25 km de Largo Alcanc, Plegable Patinete Electrico Adultos, Control de Crucero, Soporta hasta 120kg, Conexión App móvil (Negro-S9P)**

Marca: iScooter



46 valoraciones

**379<sup>99</sup> €**

Precio final del producto

**Financiación:** 97,37 € x 4 cuotas en 90 días con Paga en 4 de Cofidis (Total adeudado 389,48€, Coste del crédito 9,49€, TAE 21,52%) [Ver más](#)

**Marca** iScooter

**Color** Negro

**Límite de peso** 120 Kilogramos

**Dimensiones del producto:** 110 x 45 x 110 centímetros

**largo x**

[Ver más](#)

- What is the APR that we must pay for the scooter in case of wanting financing?
- What is the revenue they ask us for financing in 4 installments? (Cleared the revenue of the formula of the APR and make sure with your teacher that it is well cleared)
- Complete the following table that relates the frequency of payment of the installments and the revenue in percentage that we must pay for the same APR of 21.52%

Payment time	Frequency of payment of installments	Revenue in percentage that we must pay
Annual	1	
Biannual	2	
Quarterly	3	
Quarterly	4	
Monthly	12	

- It analyzes the growth or decrease of the values of this table and reasons what happens when the frequency of payment of the installments increases.



0. As students who are of mathematics we must be critical and check that all the calculations are correct. Therefore, we will carefully perform the calculations and you must:



Pasa el ratón por encima de la imagen para ampliarla

VIDEO

Cecotec Patinete eléctrico Bongo Serie A.  
Potencia máxima de 700 W, Batería Intercambiable, autonomía ilimitada hasta 25 km, Ruedas Tubeless antirreventón de 8,5", 3 Modos de conducción  
Visita la Store de Cecotec  
★★★★☆ 1.539 valoraciones  
**375<sup>67</sup> €**  
Devoluciones GRATIS  
**Financiación: 96,26 € x 4 cuotas** en 90 días con Paga en 4 de Cofidis (Total adeudado 385,04€, Coste del crédito 9,37€, TAE 21,49%) Ver más  
**Sólo queda(n) 1 en stock.**

1. Assess whether each of the processes is correct or incorrect
- b. Indicate what use has been made of the decimals (use them all, round, trick)
- c. Check if the result is the same as the ad. If not, assess what is the reason for this difference:  
To verify that the final capital is € 385.04 we must apply the second formula of which we know the initial capital and time, but we do not know the return. Therefore, from the formula of  $APR = 1 + r \cdot f \cdot t - 1$  we must clear the revenue:  
 $r = \frac{4 \cdot f \cdot TAE + 1}{t} - 1$   
We substitute and it gives us:  
 $r = \frac{4 \cdot 4 \cdot 21.49 + 1}{1} - 1 = 0.1994762005$   
We wrote it as a percentage of 19.94762005  
We now calculate the final capital by applying the corresponding formula and substituting  
 $C_f = C_0(1 + r)^n = 375.67(1 + 0.1994762005)^4 = 392.9016968$

0. With the technique of problem solving, solve the following situation: As the calculations fit you decide to request information directly from a banking agency that tells you that for the initial price of € 375.67 the APR is 10.26%.

- a. How much will you have to pay in the final principal of your 90-day loan if the frequency of payment of the installments is 4 annual payments?
- b. How much will you have to pay in the final principal of your one-year loan if the frequency of payment of the installments is 4 annual payments?
- c. How much will you have to pay in the final principal of your one-year loan if the frequency of payment of the installments is monthly?

8. We asked two banks for the financing and they gave us the following information:

Bank A: The financing of the 375.67 euros of the scooter an APR of 19.80% to be paid in 12 annual installments.

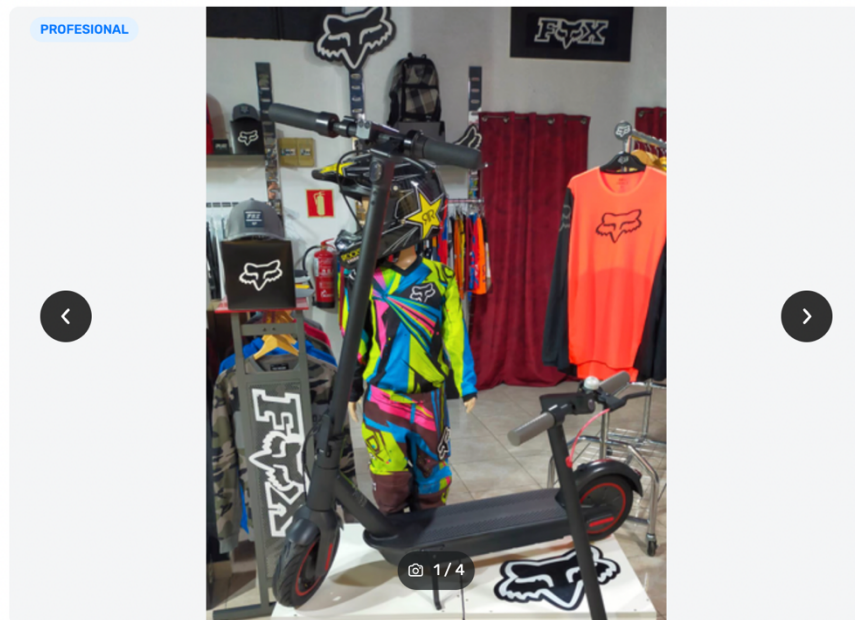
Bank B: The financing of the 375.67 euros of the scooter an APR of 10.26% to be paid in four annual installments.

With the problem-solving technique he answers:

- a. What final capital must be paid in each case?
  - b. Which bank are we most interested in and why?

9. INDIVIDUAL PRODUCT On the website of MILANUNCIOS we have found the following advertisement for the sale of an electric scooter. To ensure that the purchase has the highest quality requirements, write on a sheet of paper a manual on:

- a. What information would you look for on the Internet?
- a. What information would you ask the scooter seller?
- a. What information would you ask the bank for its financing?



**PATINETE ELÉCTRICO**



**399 €**

Nuevo patinete eléctrico IMR XMI 350W PRO MAX.

Velocidad máxima 30 kmh, autonomía 30 km, sistema de freno de disco en rueda delantera, peso 12,5 kg, carga máxima 100 kg.

Pvp 399€ (Envío gratis)

## ANNEX VII. WHAT ROUTE SHOULD I TRAVEL IF I WANT TO GO TO SCHOOL WITH MY ELECTRIC SCOOTER?

In the introduction we have read what aspects to take into account when using an electric scooter or a bicycle *"among them are safety and coexistence with other users of public roads, especially pedestrians"*. Now is the time to analyze from a mathematical point of view the routes you can make to come to school with an electric scooter following the corresponding traffic rules.

a. Read carefully:

1. the following rules of the National Directorate of Traffic on Road Safety and the electric scooter <https://revista.dgt.es/es/sabia-que/normas/2021/1214-Patinete-Equipamiento.shtml>
2. The alert of the Local Police on the regulations of electric vehicles <https://www.puertorealhoy.es/la-policia-local-alerta-sobre-la-normativa-de-vehiculos-electricos/>

a. Enter google maps and trace the route to go from your home to school on an electric scooter. Make a cutout and paste it here. It explains if the route designed by Google maps complies with the rules of the National Directorate of Road Safety Traffic.

c. Google maps indicates the time and distance between the departure point and the destination. To calculate the distance, the concept of taxi-distance is taken into account. Read carefully in a shared way the following text based on the city of Barcelona:

### *The Taxi-distance*

*"The need to measure shapes often occurs in daily life. The study of the problems raised by this activity is occupied with the mathematical discipline that the Greeks called geometry. The original Greek word, geometry, can be understood without translation: it is composed of geo, "earth," and metrien, "to measure." When we talk about geometry, it is always done in the singular. It would seem that to speak of it in the plural, geometries, would mean something like proclaiming that different dimensions coexist in the same space. It seems like an esoteric idea; However, it is so: there are different geometries.*

*Is science completely convinced of what a point... or a straight? Could it be that a circumference is shaped like a quadrilateral? Is it really known what "parallel" means?*

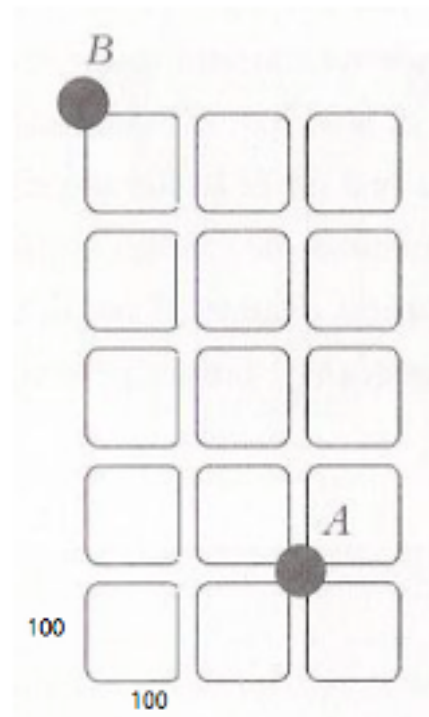
*The answers to these questions are not immutable truths, but have evolved throughout history. Euclid affirmed with total conviction that "a single parallel line passes through a point outside a line", but Lobachewski showed that a multitude of them could pass, virtually infinite. Riemann disagreed with both, and argued that there is none.*

*We will try in this text to analyze these immutable truths. A person when he goes from home to school, calculates the time it will take to get there based on the distance he must travel, and often discovers with displeasure that the calculations do not correspond to reality. The traffic, the traffic lights, the layout of the streets..., everything seems to conspire against the plans that have been made. The problem is that when you imagine the journey, you draw it in your*



*mind in a geometrically ideal way, sometimes even in almost a straight line; And reality is not geometrically ideal. It's not just crowded traffic lights or busy roads in unforeseen discharges; The calculations are determined because the blocks of houses are not perfectly square, the crossings of the streets do not describe perfect right angles ...*

*Luckily, reality is not perfectly geometric; If not, the world would be very boring, a bland repetition of orderly forms. However, order and rationality are important criteria that must be taken into account in very useful disciplines such as urban planning. For practical reasons, many current cities have favored in their urban plans structures in which the streets are configured in the form of grids. One example is the Eixample district in the Spanish city of Barcelona. The streets of the Eixample are arranged in the form of an open grid with two equidistant cut-off points. This nineteenth-century urban reform was known as Plan Cerdà. Ildefonso Cerdà (1815-1876) was a multifaceted man who dedicated his professional activity to engineering, architecture, economics, jurisprudence and politics" (Gómez, J. (2010). When the straights become curved. Non-Euclidean geometries. Spain: RBA Coleccionables, S.A. The world is mathematical.)*



Imagine a student who lives at point A of the Eixample of Barcelona and wants to go to school located at point B. If we consider that each block of houses measures 100 meters, applying the Pythagorean Theorem, we can affirm that the distance between A and B is 447.21 meters. But this is not the distance he walks, since he has to travel six hundred meters from home to school. And, if we consider that a student walks an average of five kilometers per hour with a uniform pace, it takes at least 0.12 hours; i.e. 7.2 minutes.

Thus, the actual distance between the two buildings differs from the distance to travel to go from one place to another. Thus appears a different distance concept than usual, the so-called taxi distance (taxi-distance). It may seem like a joke, but this concept of distance gave rise to taxi-geometry.

In the case of the Eixample district in Barcelona it is very easy to calculate the distance between two points because it is squared. But this is not the case of most neighborhoods in any city, or in particular Puerto Real.

In these cases, to facilitate the calculation, the maps are gridded forming scale planes. For example, the grid of the municipality of Puerto Real. This grid must allow you to locate your house, your school, calculate the distance between your home and school, calculate the taxi-distance between your home and school, approximate how long it takes you to walk. To perform the problem more easily we will think that the measurement of the side of each frame is 200 meters.

- d. Carry out the following activities applying technique 1, 2 and 4 in folios as they serve as evaluation
  1. Analyze the strategy that the author has used to define geometry. Use this strategy to define the words: trigonometry, geography, taxi-geometry.
  1. With the data you have from the text, reason mathematically if it is true that the distance between the student's house and the school is 447.21 meters, that the taxi-distance is 600 meters and that it takes 7.12 minutes.
  1. How many different ways can you go to school? Reason for your answer.

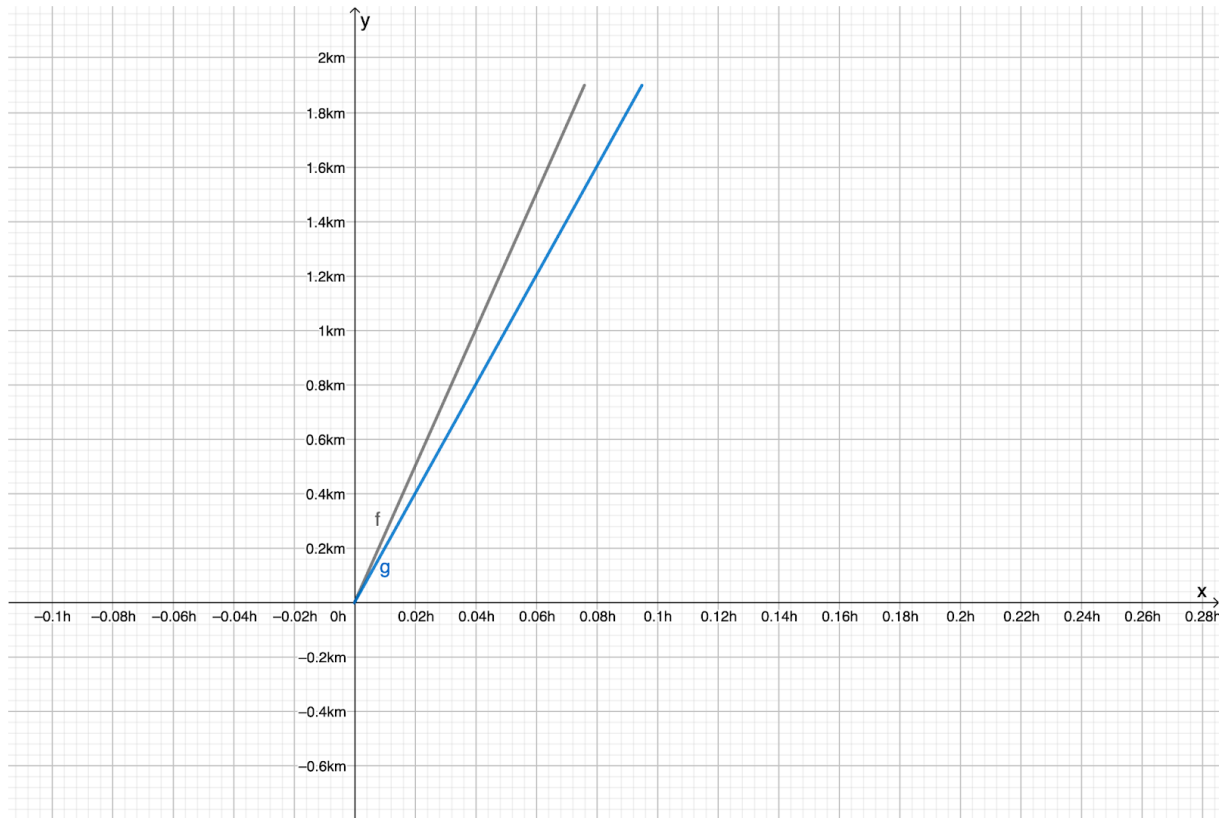


## ANNEX VIII. What is the estimated minimum and maximum time to go to school from home using an electric scooter?

1. Remember the equation that relates velocity, time, and space to a uniform velocity kinematic model. And
  - a. Apply this model in determining the minimum time needed to go from home to school with the speed that can reach the scooters summarized in the table
  - a. Calculate the estimated maximum time you will need to go to school if every time you find a zebra crossing, you need to add a maximum of 30 " of security.
  - a. Complete the following table with the calculations you have done.

Model	Maximum speed of the scooter	Minimum time needed	Estimated maximum time	Estimated average speed for the journey
Xiaomi Essential Lite	20Km/h			
Cecotec Bongo Series A	25Km/h			

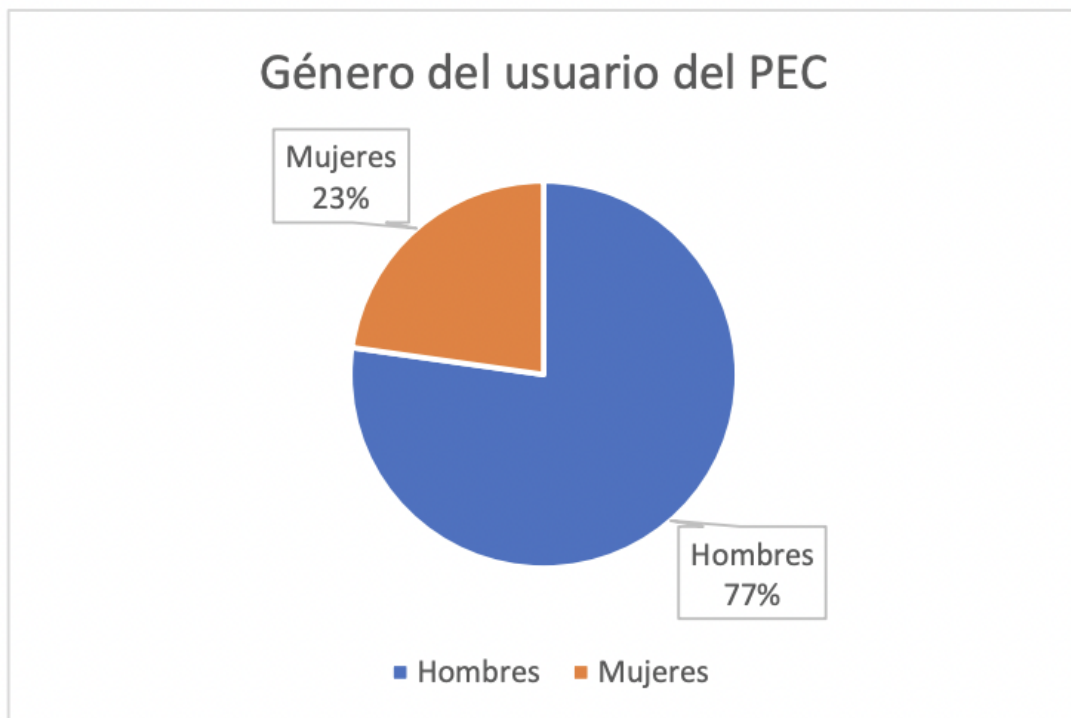
2. Below you will find a graphic corresponding to the description of the space traveled according to the minimum time necessary to go from your teacher's house to the school made with the two scooters. Argue:
  - .Which electric scooter, Xiaomi Essential Lite or Cecoted Bongo Series A, corresponds to each of the graphics?
  - .What are the magnitudes and units of measurement of the x and y axis?
  - .What is the equation of the function for each of the models that relates space, time, and velocity?



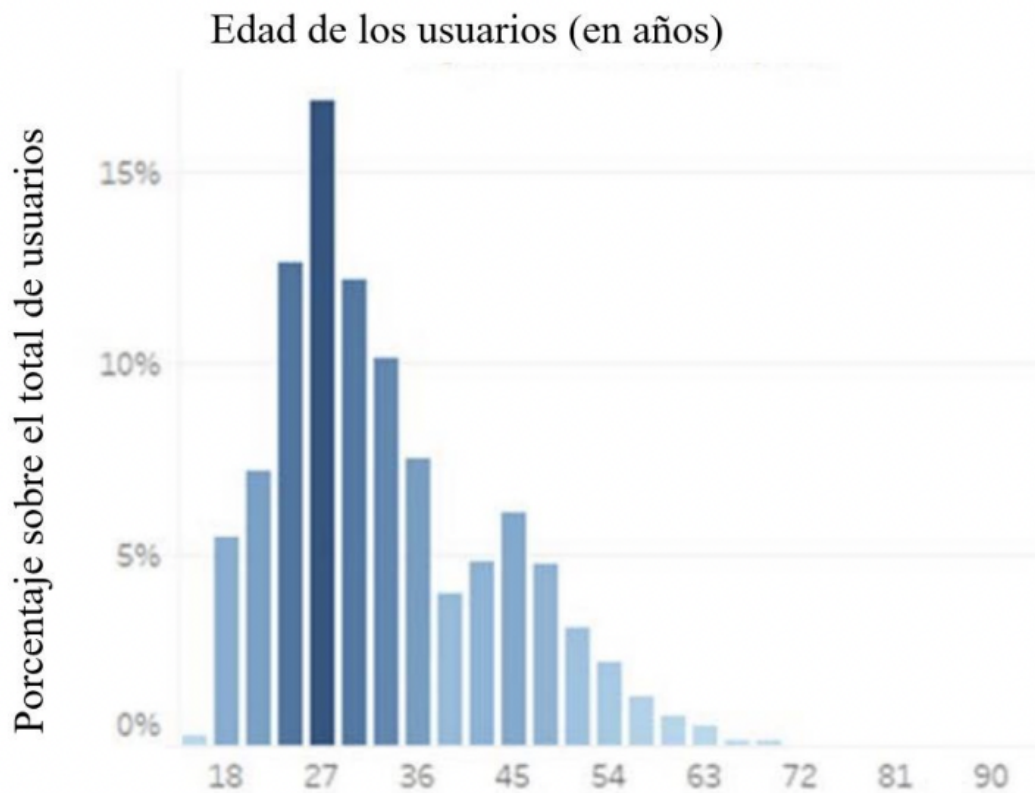
2. Represent using Geogebra (<https://www.geogebra.org/>) the corresponding graphs that describe the space-time relationship to go from home to school with the two models of scooters, Xiaomi Essential Lite or Cecoted Bongo Series A, corresponding to the minimum time necessary.

## ANNEX IX. WHAT ARE THE EFFECTS OF THE ELECTRIC SCOOTER ON HEALTH?

1. Read carefully the following graphs and tables and write a 200-word essay that answers the question: what are the effects of the electric scooter on health?



(Degele et al., 2018)



(Degele et al., 2018)

**Figura 5.** Motivos de los usuarios de patinetes eléctricos compartidos.

Objetivo del viaje (estudiantes locales)	Porcentaje
Trabajo/escuela	28%
Shopping	19%
Ocio	13%
Turismo	16%
Corta distancia	3%
Otro	21%

(Eccarius y Lu, 2018)

## ANNEX IX. LESSON 9: HOW SHOULD THE ROUTE OF AN MBOT-ROBOT COLLECTING RENTAL ELECTRIC SCOOTERS BE DESIGNED, IMPLEMENTED AND PURGED?

1. Analysis of the different components of the mBoot 2 robot
2. Application of the download processes of the desktop version mBlock and its extensions.
3. Analysis of the operating modes of the mBot2 (load and live)
4. Identification that part of the program is running on the computer in live mode (yellow halo)
5. Testing the different modes of the program loaded as standard
6. Loading the program into the robot
7. Reading and testing mBot2 sensors in "live mode"
8. Pillars of programming in robotics: sequence and how it is represented in mBlock
9. Analysis of the blocks of movements offered by the mBot2 extension
10. Create a sequence of movements so that the robot describes a trajectory that goes from Colegio La Salle-Buen Consejo to the Administrative Center of Puerto Real on an A3 scale map and undo the path.
11. Test the operation of the mBot2
12. Analysis of what happens when adjusting speeds
13. Programming of the flashing of lights when arriving at the destination point of the Administrative Center of Puerto Real
14. Programming of waiting loops to "repeat until" for the integration of the routine to be repeated depending on the number of scooters that are in the School.

