MODULE I

Lesson Plan 4

Summary

Title	
Electric mobility	
Duration	45 minutes
The age range of students	10-14

Summary of the theme

One of the main challenges facing the world's population is to reduce greenhouse gas emissions, as these contribute to climate change, which will be irreversible if the necessary measures are not taken. Among the many sources of greenhouse gas emissions, transport is one of the most important, as it has traditionally opted to use vehicles with combustion engines, which emit CO2. In addition to being negative for the environment, transport using combustion vehicles has proven to be detrimental to the health of the population. An increasingly popular alternative to this technology is the use of electric motors. These use basic concepts of electromagnetism to achieve motion without the need to emit combustion gases with a markedly higher efficiency by reducing temperature and mechanical frictional stresses. This topic deals with the construction of an electric motor to highlight its simplicity and appreciate its advantages over other less environmentally friendly technologies.

Learning outcomes

Aim/Learning Objectives.

- Apply the concept of electromagnetism in the design of an electric motor.
- Understand the advantages of electric motors over heating engines.
- Identify electric mobility as a key tool to reduce greenhouse gas emissions.

Cross-cutting objectives

- Understand the relevance of the role of science in solving real-world problems.
- To raise students' awareness of the need to take measures to reduce the environmental impact of the activities we carry out in our daily lives.

Connecting Sustainable Development Goals

This theme is aligned with SDG 11 "Make cities more inclusive, safe, resilient and sustainable" - Target 11.6: By 2030, reduce the negative per capita environmental impacts of cities, including by paying particular attention to air quality and municipal and other waste management.

Implementation

Facilitation

- Check that you have all the necessary resources available to carry out the activity before the start of the class.
- The use of gloves must be ensured whenever work with scissors is carried out.
- Please note that, as a result of manual work, both the pupils and the classroom may become dirty.
- Create the right environment to work in.
- Coordinate students so that they are motivated to participate.

Resources / Materials needed

To carry out the activity, the following materials are needed:

- One type D battery.
- Magnetic cable.
- Neodymium magnet.
- Two paperclips.
- Sandpaper.
- Insulating tape.
- Scissors.
- A thick felt-tip pen.

Ideas to continue

You can try making a coil with more windings or even try moving the neodymium magnet closer and further away. You can also try connecting a second battery in series with the first one to see what happens.

Source / Classroom materials and preparation

Video explaining the assembly process:
https://www.youtube.com/watch?v=WI0pGk0MMhg
Step-by-step development of the scientific project with theoretical explanations:
https://www.sciencebuddies.org/science-fair-projects/project-ideas/Elec_p051/electricity-electronics/build-a-simple-electric-motor

Topic outline

Time	Step-by-step instructions
5 min	Undo the folds of the paper clips, leaving them in the shape shown in Figure 1.4.1.
10 min	Attach a paper clip to the positive terminal (Figure 1.4.2) and another to the negative terminal of the battery (Figure 1.4.3). Use insulating tape for this purpose.
5 min	Wrap the magnetic wire around a thick marker pen with about 10 to 15 turns (Figure 1.4.4). Use the scissors to cut the wire, making sure that at least 3 cm is left at each end of the wire (Figure 1.4.5).
10 min	Remove the windings from the marker and bring them together. Wrap the ends around the coil to tighten all the loops as you make them, as shown in Figure 1.4.6. The coil should look as shown in Figure 1.4.7.
5 min	With the help of sandpaper, remove the entire protective layer from the cable at one end of the coil. To do this, completely embrace the cable with the sandpaper, as shown in Figure 1.4.8.
5 min	The other end of the inductor must undergo a different sanding process. In this case, only one-half of the thread is to be sanded. To do this, place the thread on the work table and make several passes with the sandpaper over the top of the thread (Figure 1.4.9). Unlike the other end, stripping the top half of the insulating material will provide a period when current can flow through the coil to create a temporary magnetic field and a period when current cannot flow, so no temporary magnetic field is created.
5 min	Carefully place the coil inside the holes of the paper clips. These will serve as a guide for the motor shaft (Figure 1.4.10). Make sure that the coil can rotate freely. Place the neodymium magnet on the battery and give it a short push to start it spinning. The electric motor is now running (Figure 1.4.11).

Formative evaluation

Classroom observations.

- Description: Teachers observe students during the elaboration of the activities.
- Objective: To assess students' level of understanding and their ability to apply the knowledge acquired in a practical activity.
- The following evaluation table is proposed:

Criterion	Excellent (5)	Very Good (4)	Good (3)	Adequate (2)	Insufficient (1)
Understanding Concepts	Demonstrates a full and thorough understanding of the activity, explaining clearly and accurately.	It shows a good understanding, with some advanced ideas or applied examples.	Understands basic concepts, with generally correct explanations.	It has a basic understanding but needs clarification on several points.	Shows little understanding of concepts, with significant errors.
Practical Skills	Performs engine construction accurately and creatively, with attention to detail and without errors.	Completes the task accurately, making minimal errors that do not affect performance.	Complete most of the steps correctly, with some minor errors.	Complete assembly with significant but functional errors.	Presents considerable difficulties, with an end product that does not meet basic requirements.
Teamwork	Collaborates exceptionally, leading, motivating, and actively helping others.	Collaborates effectively, contributing consistently and supporting colleagues.	Participates appropriately, with useful contributions and general cooperation.	Participates on a limited basis, with occasional contributions and need for guidance.	Minimal or negative participation, with little or no contribution to the team.
Active Participation	Participates actively in all activities and discussions, showing enthusiasm and curiosity.	Participates regularly, with interest and commitment evident in most activities.	Participates adequately, albeit with less enthusiasm or frequency.	Participates only when asked, showing little interest or commitment.	Participates rarely or not at all, showing obvious disinterest in the activity.
Reflection and Evaluation	Offers in-depth and critical reflections, clearly identifying lessons learned and areas for improvement.	Provides detailed reflections, with some critical ideas and suggestions for improvement.	Reflects on the process and results with a general understanding.	Reflects superficially, with few clear ideas for improvement.	Does not provide meaningful reflections or shows a lack of understanding of the process and outcomes.

Table 1.4.1 Evaluation table

Questionnaires.

- Short questionnaires at the end of the sessions to assess understanding of key concepts and the effectiveness of the activity.
- The aim is to obtain a quantitative measure of learning and retention of information.

- An evaluation table will be developed and should be adapted to the specific context of the activity and the learning objectives of the class.
- Ensure that all evaluators (if there is more than one) use the evaluation table consistently to ensure fairness in the evaluation.

Questionnaire on the activity:

1. Which statement is correct about electric motors?
   a. It burns fuel to convert thermal energy into motion.
   b. It exploits the electromagnetic characteristics of a magnet and a coil to generate motion.
   c. It needs a plug to work.
   d. It does not consume energy.
2. What are the advantages of the developed technology?
   a. It is much cleaner than a combustion engine, although it is more complex.
   b. It is clean and simple but has very low efficiency.
   c. It is cleaner, simpler, and more efficient than a combustion engine.
   d. It does not need electrical power to operate.
3. How can the implementation of this technology improve the planet?
   a. It reduces greenhouse gas emissions.
   b. Although it pollutes more, it is cheaper.
   c. It has not had any improvement over traditional technologies.
   d. None of the above is correct.

Answers:

b) It exploits the electromagnetic characteristics of a magnet and a coil to generate motion.
c) It is cleaner, simpler, and more efficient than a combustion engine.
a) It reduces greenhouse gas emissions.

Feedback

Net Promoter Score (NPS) is a widely used tool to measure the loyalty and satisfaction of customers or, in an educational context, students. It measures the likelihood that students will recommend the subject or course to others.
How to analyse and apply NPS is explained below:

Development of the NPS question:

- Main question: "On a scale of 0 to 10, how likely are you to recommend this topic to other students?
- Follow-up questions: "Why did you select this score?" and "How can we improve this issue?

Collection of responses:

- Digital surveys: Use online tools such as Google Forms, SurveyMonkey, or Typeform to collect student responses.
- Paper surveys: Paper questionnaires are distributed at the end of the lesson for students to complete. A template for collecting responses with paper surveys is shown in the Annex.
- Interactive applications: Interactive applications such as Quizziz, Mentimeter, or Kahoot! are used to collect answers in real time.

Classification of responses:

- Promoters (Score 9-10): Students are very satisfied and likely to recommend the subject.
- Passive (score 7-8): Satisfied but not enthusiastic students; they could easily change their minds.
- Detractors (Score 0-6): Dissatisfied students who are unlikely to recommend the subject; they could provide constructive criticism.

Calculation of NPS:

- Formula: NPS = % of promoters - % of detractors.
- Score interpretation: NPS ranges from -100 to +100. A positive score (above 0) is generally good, and a score above 50 is excellent.

Analysing and using comments:

- Review the comments to understand the reasons behind the scores.
- Identifies patterns and specific areas for improvement among detractors and passives.
- Use the promoters' positive comments to reinforce the positive aspects of the issue.

Annexes

This Annex shows the Figures that represent the development of the proposed activity.

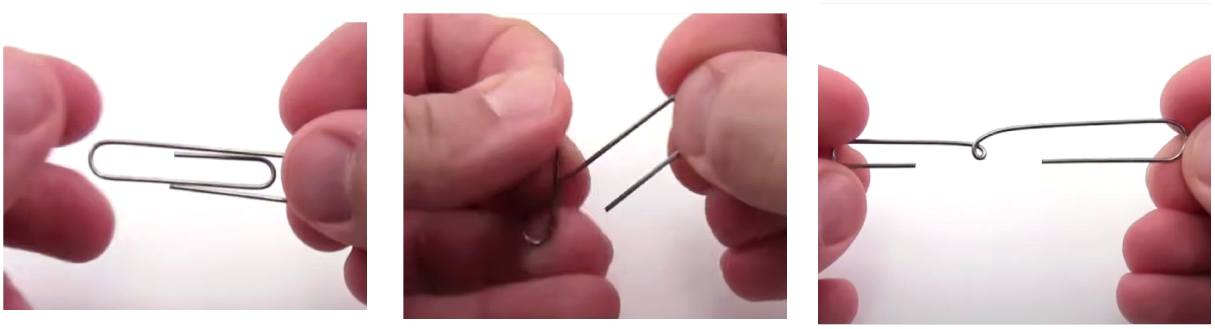


Figure 1.4.1 Unfolding of paper clip. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg



Figure 1.4.2 Placing the paper clip on the positive terminal of the battery. Link:



https://www.youtube.com/watch?v=WI0pGk0MMhg

Figure 1.4.3 Placing the paper clip on the negative terminal of the battery. Link:
https://www.youtube.com/watch?v=WI0pGk0MMhg



Figure 1.4.4 Magnetic cable winding. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

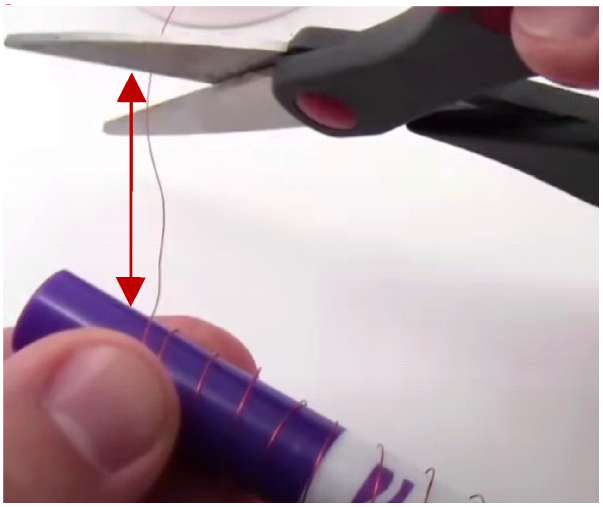


Figure 1.4.5 Cutting the ends. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

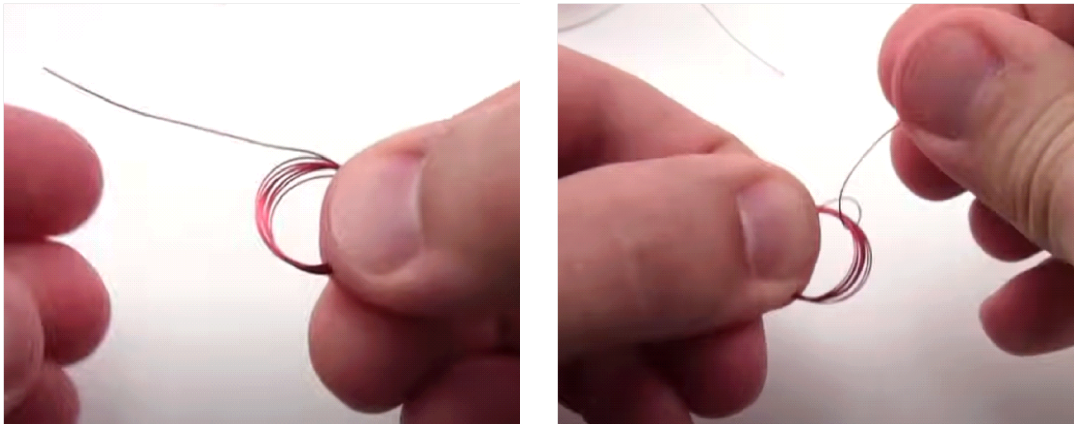


Figure 1.4.6 Magnetic cable termination. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

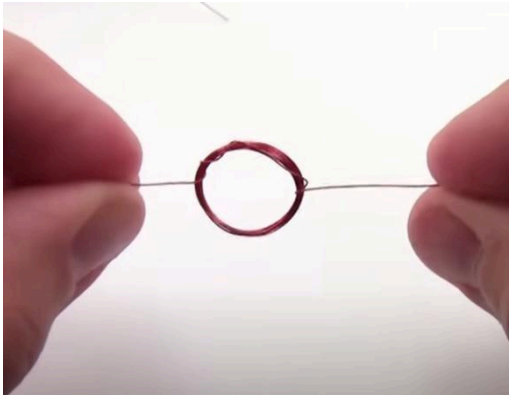


Figure 1.4.7 Magnetic cable termination. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

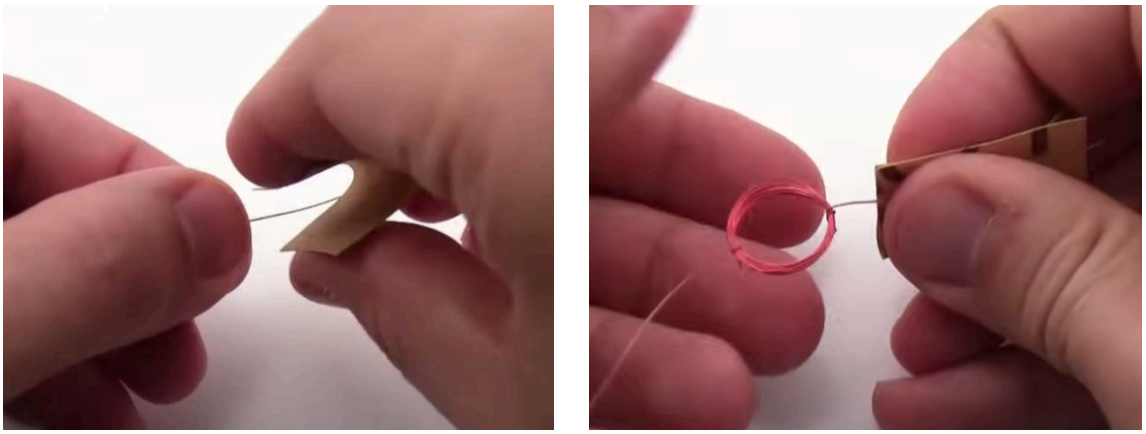


Figure 1.4.8 Complete sanding of one end of the coil. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

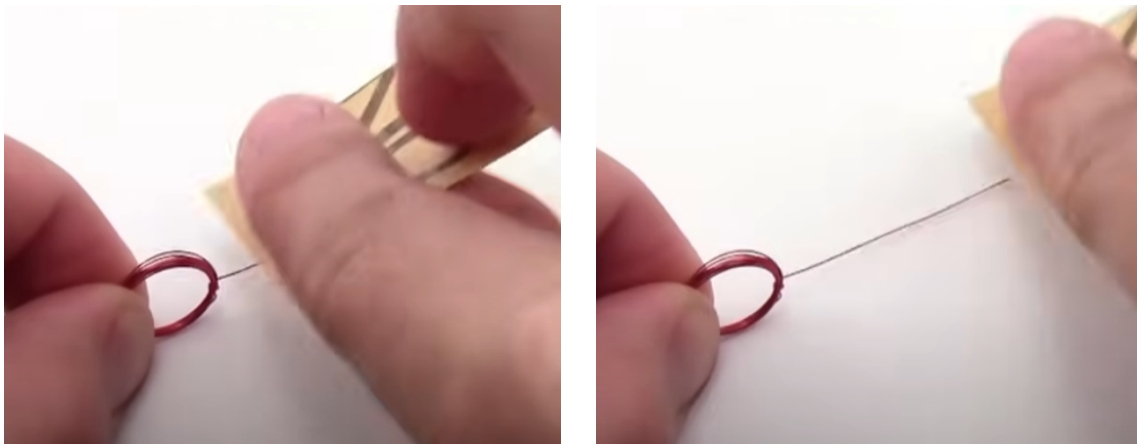


Figure 1.4.9 Sanding half of the wire on the second end of the coil. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

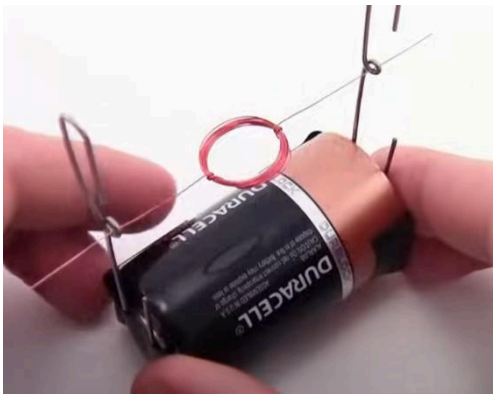


Figure 1.4.10 Placing the inductance on paper clips. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

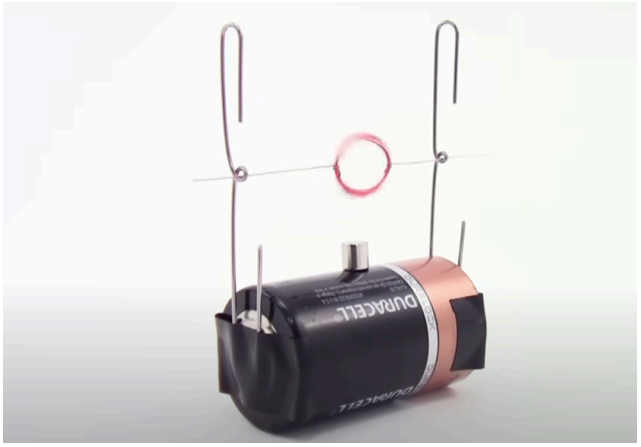


Figure 1.4.11 Engine start-up. Link: https://www.youtube.com/watch?v=WI0pGk0MMhg

QUESTIONNAIRE TO COLLECT FEEDBACK ON THE TOPIC

On a scale of 0 to 10, how likely would you recommend this subject to other students?

0	1	2	3	4	5	6	7	8	9	10

Not likely at all — Extremely likely

Why did you choose that score?

How could this issue be improved?