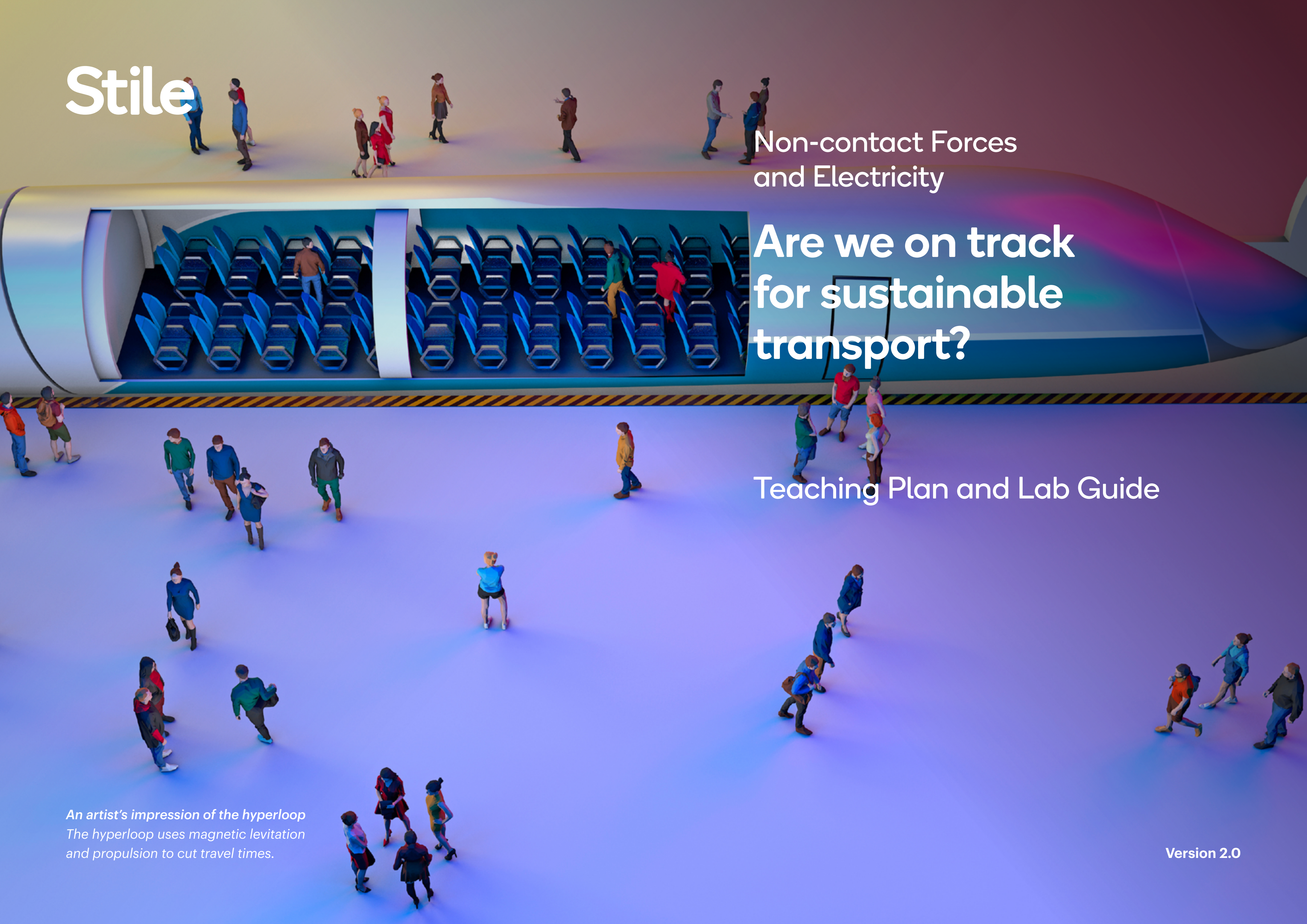
Stile



Non-contact Forces and Electricity

Are we on track for sustainable transport?

Teaching Plan and Lab Guide

An artist's impression of the hyperloop
The hyperloop uses magnetic levitation and propulsion to cut travel times.

Version 2.0

Contents

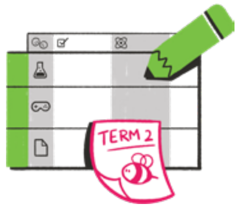
Teaching plan

Lab Guide

Everything in one place

Stile is a complete science curriculum. Our digital lessons and hard-copy booklets are designed to help students be the best learners they can be and to give you the tools to do what you do best: teach.

Before class



Teacher resources

Find out everything you need to know from the unit's **Teaching Plan** and **Lab Guide**.

In **Prepare Mode** for each lesson, you can:

- Read the detailed teaching notes
- Print a copy to refer to in class
- Customise resources for the needs of your students

Student resources

Stile X phone app

- Front-load the unit's scientific terminology through flashcards and quizzes

During class

Teacher resources

Within **Teach Mode** you can:

- Implement explicit teaching with learning goals and Key Questions
- Use videos, images and text to guide your instruction
- Facilitate discussion with live brainstorms and polls
- View student data instantly to inform your teaching

Student resources

Stile Classroom

- Engage in real-world phenomena through:
  - Practical activities
  - Research projects
  - Classroom lessons
  - Hands-on activities
  - Breaking news
  - Extension lessons
  - Engineering challenges
  - Open-ended investigations

After class

Teacher resources

To **Analyse** student work:

- View data in Analyse Mode to determine your next teaching steps
- See a bird's-eye view of student progress in the Markbook
- Release model answers to students
- Provide written feedback where it matters most

Student resources

Stile X booklets

- Consolidate and revise material learned in class by:
  - Creating structured revision notes
  - Recording definitions in the glossary
  - Completing practice test questions

Stile X phone app

- 60-second summary videos recap key ideas from the Stile lesson

Scan here to view **The Stile Guide**, the essential guide to supercharging your teaching with Stile

Ferrofluid interacting with a magnetic field
Ferrofluid is a colloid containing fine magnetic particles.

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Teaching Plan

Storyline and real-world phenomenon

Is there a better way to travel?

Every day, billions of people around the world move from place to place using cars, buses, trains or planes. These modes of transport are convenient, but are they doing more harm than good? Is there a better way to get around?

In this unit, students will work as engineers to create a better mode of transport. Harnessing the power of non-contact forces, this new mode of transport could be one important step forward in solving our transport crisis.

Big ideas

- How do engineers develop solutions to solve problems?
- What are the different types of non-contact forces?
- How do magnets move objects at a distance?
- Can you create a magnet using an electric current?
- How do the electric circuits in electric cars work?

Highlights

- Map invisible fields using iron filings
- Apply non-contact forces to win a no-hands tug-o-war
- Investigate the forces at play in a magnetic accelerator
- Build series and parallel circuits using a simulation

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This unit at a glance

This unit is designed to take four and a half weeks, with four 45-minute class sessions per week.

- Classroom lesson
- Extension lesson
- Pre-test
- Check-in
- Glossary
- Test
- Breaking news
- Practical activity
- Research project
- Hands-on activity
- Engineering challenge
- Open-ended investigation

This icon indicates lessons that have additional revision and consolidation material available in **Stile X**, our hard-copy study booklet and accompanying app.

Non-contact Forces and Electricity

1. Is there a problem with how we travel?
2. Engineering challenge: What will you solve?
3. Magnetic slime: Can you lift slime without touching it?
4. Electrostatic forces: Are magnets the only solution?
5. Magnetic accelerators: Can you boost your transport system?

Check-in #1

6. Magnetic fields: How do magnets interact?
7. Electromagnetic trains: Can magnetism keep our train moving?
8. Electromagnets: How can we make an electromagnet?

Check-in #2

9. Engineering challenge: Creating a prototype
10. Engineering challenge: Testing your prototype
11. Engineering challenge: Communicating your solution
12. Electric motors: How does an electric car work?
13. Electric circuits: What are they?
14. Ohm's law: What's going on inside a wire?
15. Series and parallel: Is there another way to make a circuit?

Check-in #3

Glossary: Non-contact forces and electricity

Test: Non-contact forces and electricity

Students engage in the **real-world issue** of **sustainability and engineering**.

Students use **models to observe invisible forces** and discuss the limitations of modelling.

Students **observe phenomena** through playing games to make sense of non-contact forces.

This **summative assessment** assesses students' curriculum-aligned knowledge.

Students **formulate testable questions** that can be explored using magnetic slime.

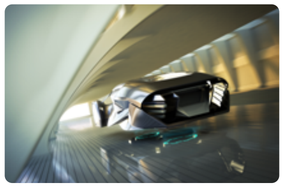
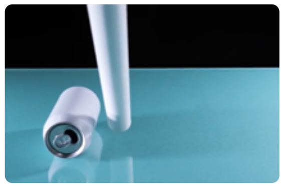
Students **create and problem-solve** to discover the relationships between the strength of electromagnets and design factors.

Students **engage in the engineering process** to improve their own ideas and designs for a sustainable travel future.

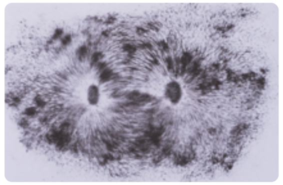
Regular **formative assessments** provide quick checks of student progress throughout the unit.

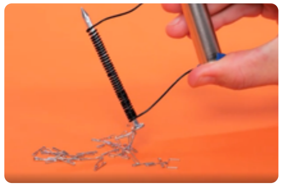
Unit storyline

Throughout this unit, students will work as engineers to create a more sustainable mode of transport. Harnessing the power of non-contact forces, this new mode of transport could be one important step forward in solving our transport crisis. The use of multiple phenomena supports students to develop scientific skills and understanding. The progression of these phenomena, and how they are observed within lessons, is detailed below.

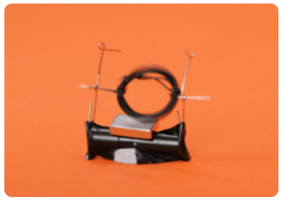
Phenomenon	Lesson
Travel and transport are damaging the environment 	**1. Is there a problem with how we travel?** – Students explore problems with our current modes of transport, which prompts them to recognise the emissions being created and polluting our cities – They evaluate the potential of the hyperloop and how this could address our transport issues
Creating a new transport solution using non-contact forces 	**2. Engineering challenge: What will you solve?** – Students are introduced to the problem they will work to solve over the course of the unit – As the lessons progress they will be exposed to a range of non-contact forces, which allows them to later design and evaluate their solution for the current transport crisis. By unpacking the challenge prior to their learning they can consider the task throughout their learning
Magnets can move objects from afar 	**3. Magnetic slime: Can you lift slime without touching it?** – Students must be comfortable manipulating magnetic interactions to solve the current transportation problem – They make magnetic slime and explore the phenomena of attractive magnetic forces – This will help them build towards understanding more complex interactions of non-contact forces for future transport options
Gravity and electrostatic forces act at a distance 	**4. Electrostatic forces: Are magnets the only solution?** – Students explore other non-contact forces, gravity and electrostatic forces, they may encounter to help solve the transport crisis – They compare and contrast the forces to determine which is the most appropriate to move a vehicle long distances

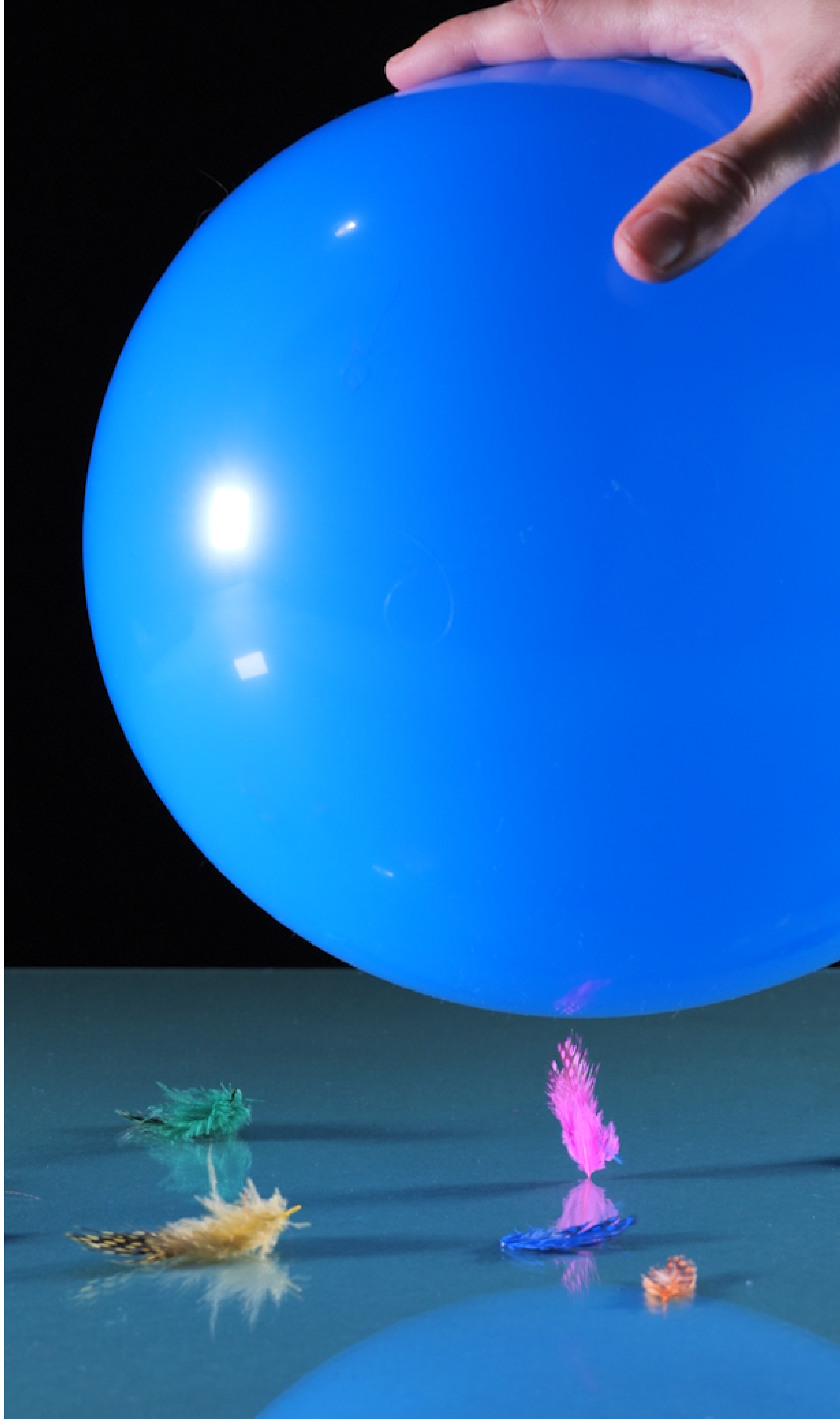
Unit storyline

Phenomenon	Lesson
Magnets attract and repel allowing the creation of magnetic accelerators for sustainable transport 	**5. Magnetic accelerators: Can you boost your transport system?** – Students investigate one way they could speed up their transport solution using magnetic accelerators – They will apply their understanding of attraction and repulsion to explain the optimal magnetic accelerator design – Use of this in their final design could be a key to meeting one or more of the requirements of the design brief
Magnetic fields explain how magnets interact due to non-contact forces 	**6. Magnetic fields: How do magnets interact?** – Students map the magnetic fields of magnets and investigate how two magnetic fields can interact – Observations allow them to visualise the invisible fields that govern these non-contact force interactions

Phenomenon	Lesson
The role of electro-magnetism in keeping sustainable transport moving 	**7. Electromagnetic trains: Can magnetism keep our train moving?** – Students explore how electromagnetism can keep their train moving when it isn't near the accelerator – Through Oersted's experiment they establish that electric currents can create a magnetic field, establishing another way a train could move
The importance of controlling and harnessing the strength of an electromagnet for future transport 	**8. Electromagnets: How can we make an electromagnet?** – Student construct an electromagnet and then investigate how to change the strength – They then consider how this assists with their transport solution

Unit storyline

Phenomenon	Lesson
Using non-contact forces to design a sustainable transport solution  	**Engineering challenge:** – Students apply all the knowledge and skills developed throughout the unit to create their transport solution – They will create, test, evaluate and improve their prototype then report back on their solution
Explore a sustainable transport solution already being used: the electric motor 	**12. Electric motors:** **How does an electric car work?** – Now that students have created their sustainable transport solution the remaining lessons will pivot to look at how electric motors are already helping address this problem and expose students to electricity concepts – Students will create a simple electric motor to explain how it works



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Curriculum alignment

This unit focuses on future sustainable transport solutions while exploring how non-contact forces and electricity will contribute to the solution.

Detailed alignment information can be found at the links below.

Click here to view curriculum alignment for Version 8.4 of the Australian Curriculum

Click here to view curriculum alignment for Version 9 of the Australian Curriculum

Click here to view alignment for the NSW Syllabus for the Australian Curriculum

Click here to view curriculum alignment for the Victorian Curriculum

Click here to view curriculum alignment for the Western Australian Curriculum

Prior knowledge

This unit is written with the assumption that students have some existing subject knowledge.

Before beginning this unit, students should be familiar with:

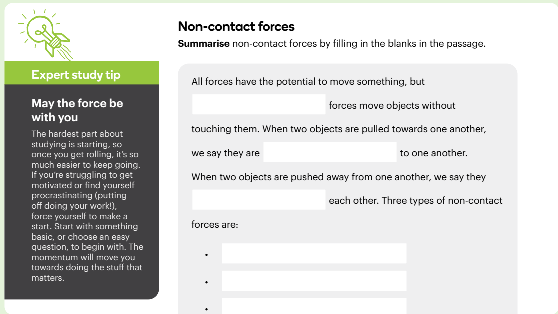
- The types of forces as well as balanced and unbalanced forces (**Forces** unit)
- Knowledge of electrical circuits and the idea of causation (**Magnetism** unit)

Stile X: Non-contact forces and Electricity

What's in the Stile X booklet?

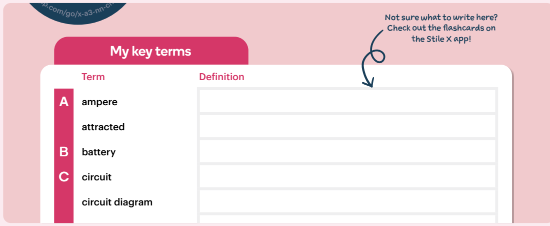
Model how to complete the structured **revision notes** as students fill in sections of these pages in class. Any remaining sections can be done at home before the next lesson. As students become more familiar with Stile X, increase independent use both at home and in class.

This unit includes **revision notes** for:
- Are magnets the only solution?
- Can you boost your transport system?
- How do magnets interact?
- What are electric circuits?
- What's going on inside a wire?
- Is there another way to make a circuit?

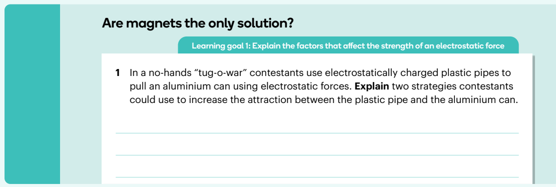


Read **expert study tips** aloud and discuss them in class to help students build important study skills.

When you see a bolded word in Stile, ask students to turn to the **glossary** pages to record the definition in their own words.



The **practice test** is perfect for revision. Fast finishers can even complete questions as an extension activity during class time. Each question addresses a learning goal from the unit's core lessons.
- Explain the factors that affect the strength of an electrostatic force
- Justify which non-contact force is most helpful for your transport solution
- Use data to explain which arrangement of magnets makes the best accelerator
- Explain how the distance between magnets changes the forces between them
- Explain the limitations of modelling magnetic fields
- Explain how the strength of the force varies around a magnet
- Create a circuit diagram of a dodgem car
- Explain the factors that affect the flow of current through a circuit
- Design a circuit diagram to solve a problem using Ohm's law
- Explain the advantages and limitations of different circuits
- Evaluate the design of an electric circuit



Assessment

Stile's assessment tasks require students to apply general capabilities, skills and knowledge to explain phenomena and solve problems. We recommend using the formative assessment opportunities listed to gauge student progress, which will guide your next teaching steps. Self-assessment opportunities are also included in both Stile and Stile X to encourage metacognitive monitoring. Summative assessment tasks are designed to show what a student has learned throughout the unit and can be used to inform your reporting.

Formative assessment

Key Questions

A Key Question is an opportunity for students to demonstrate their progress against a learning goal. Stile lessons include one Key Question for each learning goal. Using the in-class analytics available in Teach Mode, you can use Key Questions to make quick, frequent judgements about student progress. We strongly recommend that you focus on these questions when providing written feedback.

Check-ins

Three check-in lessons have been included as formative assessment opportunities in the unit. Check-ins contain self-marking multiple choice and drag and drop questions that will give you a quick snapshot of student learning at pivotal points in the unit. Student results in a check-in assessment will help you determine whether students are ready to progress to the next phase in the learning cycle, or whether further teaching is required.

Lesson type	Lesson name	Question types	Time
Check-in	Check-in #1	Multiple choice, drag-and-drop	5–10 minutes
Check-in	Check-in #2	Multiple choice, drag-and-drop	5–10 minutes
Check-in	Check-in #3	Multiple choice, drag-and-drop	5–10 minutes

Summative assessment

Test

This unit contains a test to provide summative assessment of student learning across the whole unit.

Lesson type	Lesson name	Question types	Time
Test	Test: Non-contact forces and electricity	Multiple choice, drag and drop, written response	65 minutes

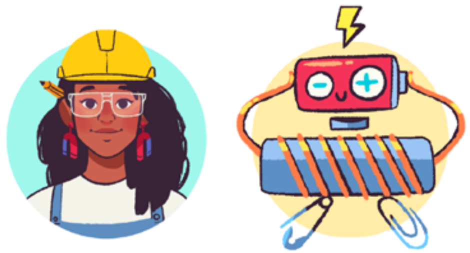
Scientific skills

One project within this unit can be used as a summative assessment of science inquiry skills.

Lesson type	Lesson name	Question types	Time
Engineering challenge	Lesson: 2. Engineering challenge: What will you solve?	Drag and drop, written response	40 minutes
Engineering challenge	9. Engineering challenge: Creating a prototype	Written response	50 minutes
Engineering challenge	10. Engineering challenge: Testing your prototype	Written response	80 minutes
Engineering challenge	11. Engineering challenge: Communicating your solution	Written response	40 minutes, plus 10 minutes of presentation time per group

Important things to know about this unit

Character conversations

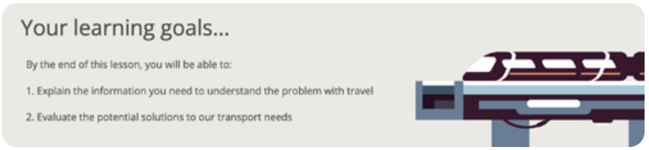


Magnetic Maggie and Robot are included throughout the unit, and speech bubbles are used as a bridge between sections of the lesson and to provide light humour. Where character conversations appear, they should be read in the same way as other sections of text. You might read the conversations aloud, or ask students to "play" the role of a specific character within the lesson.

The role of the guiding question

Student curiosity and questioning drive the learning in this unit. Students frequently contribute their questions to live brainstorms, and these questions are drawn upon to drive the learning from the students' perspectives. The guiding question, "Is there a better way to travel?" is introduced in Lesson 2 (Lesson: 2. Engineering challenge: What will you solve?). It acts as a support around which you can facilitate discussion, and support students to connect their own questions to the targeted materials.

Learning goals



While student curiosity and questioning drive the learning, the design of the unit as a whole supports students to make sense of phenomena and design solutions. The use of learning goals guides them towards specific outcomes in each lesson, so that their learning builds towards understanding the phenomenon and designing a solution to the problem. Evidence shows that students who know what is expected of them are more likely to engage in the learning process and achieve better learning outcomes (Hattie, 2012). These goals are introduced following an initial opportunity for students to explore the phenomenon, so that the opportunity for inquiry is maintained.

Engineering challenge

This unit culminates in an engineering challenge where students design one aspect of a futuristic transport solution. The engineering challenge focuses on students' ability to test, evaluate and improve upon a design. By exploring how simple magnetic interactions affect the function of an electromagnetic train, students will be able to demonstrate an understanding of the engineering process and apply their knowledge of non-contact forces in a new context. By drawing upon and modifying experiments they've seen throughout the unit, all students have an opportunity to experience success. Students who are interested in challenging themselves can also go into great detail in explaining the more complex interactions, allowing for rich extension opportunities. Detailed advice on how to run the engineering challenge, as well as possible student outcomes, alternative approaches to reduce materials and how to emphasise the engineering process, can be found in the **Lab Guide**.

Important things to know about this unit

Parent email template

This unit includes a pre-written email template that you can use to inform parents about what students are learning in class. You'll find a link to this template in the teacher notes at the bottom of the unit's folder in your Stile subject or you can go to **stileapp.com/go/parentemailncf**

Copy the text, paste it into an email, and modify it to suit. This is a great way to bridge the gap between school and home, and engage parents in their child's learning.

Resources

Lab Guide
The end of this document contains a lab guide that includes the materials and methods for this unit's hands-on and practical activities. Pages from the lab guide are also linked in the teaching notes of the relevant Stile lesson.

For each practical activity, hands-on activity, engineering challenge or open-ended investigation you'll find:
- Demo videos, which can be viewed before class to help with preparation, or shown to students during class for extra scaffolding
- Handy tips and tricks for making the activity a success
- A RiskAssess template
- An expected final outcome

Stationery
The following lessons require students to brainstorm and/or draw and create using paper, so they will need the stationery below.

9. Engineering challenge: Creating a prototype
- Butcher's paper
- Pens, pencils, markers

11. Engineering challenge: Communicating your solution
- Poster paper
- Pens, coloured pencils, markers

Student supplies
Each student will need:

- A device to access Stile lessons
- A Stile X booklet for this unit
- A pen or pencil to complete answers in Stile X
- Coloured pencils to complete mindful colouring activities in Stile X

Non-contact forces and electricity: Essentials kit

To help students explore the complex interactions of non-contact forces in this unit, we've filled the unit with practical activities and investigations. To help you have everything you need to run those activities, we've created the Non-contact forces and electricity: Essentials kit. The kit contains the important materials that are most difficult to find and prepare. Paired with common materials you will likely already have around the classroom, you'll be armed with everything you need to make this unit a success.

Lesson Planning Guide

Week 1 · Week 2 · Week 3 · Week 4 · Week 5

The guide below is based on four 45-minute sessions per week.

Click here to download an editable version of this planning guide.

	Lesson name	Learning goals	Preparation required	Ice breaker	Core of lesson	To close	Revision and mastery
Session 1	**1. Is there a problem with how we travel?**	1. Explain the information you need to understand the problem with travel 2. Evaluate the potential solutions to our transport needs	Review teaching notes in Prepare Mode Collect Stile X booklets for this unit Find out more about using Stile X in **The Stile Guide** **Send parent email template** 10 minutes	Explain that you are starting a new unit about non-contact forces and electricity, and students will discuss air pollution in Los Angeles based on two photos at different points in time	Students look at issues with our current transport model to become invested in the problem of emissions from transport	As a class, look at the proposed hyperloop and its potential as a solution for the transport problem Hand out Stile X booklets and activate Stile X app	Stile X app: Flashcards Glossary terms: constraints, criteria
Session 2	**2. Engineering challenge: What will you solve?**	1. Explain how engineering solutions can solve today's transport problems 2. Justify how you will design your future transport solution	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode 10 minutes	As a class, watch the video of cars driving in winter and complete the live brainstorm on what problems people encounter while driving	Introduce students to the *Creative Questions* thinking routine and encourage them to come up with at least one question for each of the three prompts	Ask students to think about a job they would like to do in the future and get them to identify any challenges they might face as well as how they can be overcome	Stile X app: Flashcards Glossary terms: non-contact forces
Session 3	**3. Magnetic slime: Can you lift slime without touching it?** MATERIALS REQUIRED	1. Determine a testable question relating to investigating magnetic slime 2. Discuss how magnetic pull can be increased	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	In groups, students will make magnetic slime	Students problem- solve to modify the independent variable to make their slime more magnetic	Ask students to list questions they have about magnets being part of their transport solution	Stile X app: Flashcards Glossary terms: testable question
Session 4	**4. Electrostatic forces: Are magnets the only solution?** MATERIALS REQUIRED	1. Explain the factors that affect the strength of an electrostatic force 2. Justify which non-contact force is most helpful for your transport solution	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, watch the video on electrostatic forces using a balloon and PVC pipe, then complete the live brainstorm about wonderings from what they've just watched	Students carry out the no hands "tug-o-war" and then compare magnetic force, electrostatic force and gravity Direct students to the corresponding Stile X revision notes to complete the question: Summarise non-contact forces by filling in the blanks in the passage	As a class, reflect on the questions posed while watching the video at the start of the lesson and answer any still left unanswered	Stile X app: Flashcards Stile X app: Are magnets the only solution? video Stile X Revision notes: Are magnets the only solution? Glossary terms: magnetic force, electrostatic force

	Lesson name	Learning goals	Preparation required	Ice breaker	Core of lesson	To close	Revision and mastery
Session 5	**5. Magnetic accelerators: Can you boost your transport system?** MATERIALS REQUIRED	1. Use data to explain which arrangement of magnets makes the best accelerator 2. Explain how the distance between magnets changes the forces between them	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, watch the video of the magnetic accelerator and then complete the *Think, Puzzle, Explore* Visible Thinking routine	Students investigate the arrangement of magnets in a magnetic accelerator for maximum distance Direct students to the corresponding Stile X revision notes to complete the question: Label the diagram to show the parts of a magnetic accelerator, using terms from the text	Ask students to suggest how a magnetic accelerator could be part of their sustainable transport solution Assign **Check-in #1** as homework to be completed before the next lesson	Stile X app: Flash Quiz 1 Stile X app: Can you boost your transport system? video Stile X Revision notes: Can you boost your transport system? Glossary terms: pole, attracted, repelled
Session 6	**6. Magnetic fields: How do magnets interact?** MATERIALS REQUIRED	1. Explain the limitations of modelling magnetic fields 2. Explain how the strength of the force varies around a magnet	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, review answers to **Check-in #1**	Students model magnetic fields using iron filings and see how different fields interact with one another Direct students to the corresponding Stile X revision notes to complete the question: Explain whether the two magnets that created this pattern are attracting or repelling each other	Ask students to complete the Key Question to review magnetic accelerators but also visualise how the magnetic fields are interacting during this event	Stile X app: Flashcards Stile X app: How do magnets interact? video Stile X Revision notes: How do magnets interact? Glossary terms: magnetic field
Session 7	**7. Electromagnetic trains: Can magnetism keep our train moving?** MATERIALS REQUIRED	1. Explain how a strong magnetic field can be produced without magnets 2. Justify how the structure of a system affects the way it functions	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, watch the video on a simple train using a magnet and a battery and then complete the *Creative Questions* Visible Thinking routine	Students construct an electromagnetic train and explore how it moves using different configurations	Ask students to reflect on how electromagnetism could help with their sustainable transport solution	Stile X app: Flashcards Glossary terms: electromagnet, electromagnetic force
Session 8	**8. Electromagnets: How can we make an electromagnet?** MATERIALS REQUIRED	1. Plan an investigation to change the strength of an electromagnet 2. Describe the relationship between variables in your investigation 3. Use data to explain the relationship between current and electromagnetic force	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, watch the video of an electromagnet in action at a waste processing facility and then complete the *See, Think, Wonder* Visible Thinking routine	Students make an electromagnet and then investigate changing the independent variable: its strength	Ask students to consider how changing variables of an electromagnet could affect how an object moved Assign **Check-in #2** as homework to be completed before the next lesson	Stile X app: Flash quiz 2 Glossary terms: magnetised, permanent magnet

	Lesson name	Learning goals	Preparation required	Ice breaker	Core of lesson	To close	Revision and mastery
Session 9	**9. Engineering challenge: Creating a prototype**	1. Create a design for a sustainable transport solution 2. Explain the processes used to evaluate engineering solutions	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials: butcher's paper and pens/pencils/markers 20 minutes	As a class, review answers to **Check-in #2**	Students summarise what they have learnt about non-contact forces, review their engineering challenge and then design their first prototype for their sustainable transport solution	Encourage students to prepare for the next lesson by identifying what part of their solution they will build a prototype for and any materials that they will need	Stile X app: Flashcards
Session 10	**10. Engineering challenge: Testing your prototype** MATERIALS REQUIRED	1. Evaluate the effectiveness of your design 2. Explain how the improvements you made created the optimal solution	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the materials that students listed at the end of the previous lesson Complete the **Risk Assessment Template** 30 minutes	Students will participate in the live brainstorm describing a time they have failed and then learned something that allowed them to perform better the next time	Students choose one section of their design to build, this will allow them to test, evaluate and improve their sustainable transport model	Encourage students to redraw their improved design and upload this as the final version	Stile X app: Flashcards
Session 11	**10. Engineering challenge: Testing your prototype** MATERIALS REQUIRED	*Continued*	*Continued*	*Continued*	*Continued*	*Continued*	*Continued*
Session 12	**11. Engineering challenge: Communicating your solution** MATERIALS REQUIRED	1. Create a poster that displays all of your key learnings 2. Propose how you could integrate other solutions for an optimal design	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the materials: poster paper, pens/markers/pencils, printed assessment rubrics, printed peer assessment rubrics 20 minutes	As a class, revise what is important to keep in mind when communicating your findings	Students design a poster sharing their sustainable transport solution and self-assess their work	As a class, discuss the 4 C's (connections, challenges, concepts, changes) and then use sticky notes for students to justify how they could combine other student ideas to create an even better sustainable transport solution	Stile X app: Flashcards

	Lesson name	Learning goals	Preparation required	Ice breaker	Core of lesson	To close	Revision and mastery
Session 13	**12. Electric motors: How does an electric car work?** MATERIALS REQUIRED	1. Explain how an electric motor moves	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode Collect the required materials listed in the **Lab Guide** Complete the **Risk Assessment Template** 30 minutes	As a class, watch the video of the electric car, review the diagram of the inner workings of an electric car, watch the electric motor model video and then get students to observe and infer what they have seen	Students work collaboratively to create a simple electric motor and then describe how it moves and explore how it works	Students complete a *Connect, Extend, Challenge* table to explain how the electric motor connects to what they have already learnt about sustainable travel	Stile X app: Flashcards Students can complete the **Skill builder: Observing and inferring** for additional support with making observations and inferences
Session 14	**13. Electric circuits: What are they?**	1. Create a circuit diagram of a dodgem car	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode 20 minutes	As a class, watch the video of dodgem cars and review the diagram, they will then brainstorm how they propose dodgem cars work	Students examine electric current and electric circuits to then communicate how dodgem cars work using circuit diagrams Direct students to the corresponding Stile X revision notes to complete the question: Describe what is meant by electric current by placing words from the box in the gaps in the paragraph	Ask students to use the *Curious Questions* thinking routine to reflect on questions they may still have on this topic	Stile X app: Flashcards Stile X app: What are electric circuits? video Stile X Revision notes: What are electric circuits? Glossary terms: electric current, ampere, circuit
Session 15	**14. Ohm's law: What's going on inside a wire?**	1. Explain the factors that affect the flow of current through a circuit 2. Design a circuit diagram to solve a problem using Ohm's law	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode 20 minutes	As a class, watch the video of an electric car accelerating and then have a discussion by asking students to share anything they notice that relies on batteries	Students explore what affects the flow of current to explain how voltage and resistance affect the current, and then look at Ohm's law Direct students to the corresponding Stile X revision notes to complete the question: Identify the definition of each word by drawing a line to connect the definition and unit of measurement	Encourage students to begin thinking about how circuits can be arranged by asking if a single battery could send power to several different components individually	Stile X app: Flashcards Stile X app: What's going on inside a wire? video Stile X Revision notes: What's going on inside a wire? Glossary terms: voltage, resistance, resistor, Ohm's law
Session 16	**15. Series and parallel: Is there another way to make a circuit?**	1. Explain the advantages and limitations of different circuits 2. Evaluate the design of an electric circuit	Provide feedback on the Key Question from the previous lesson in Analyse Mode Review teaching notes in Prepare Mode 20 minutes	As a class, watch the video of the interior of an electric car and ponder what makes it possible for each accessory in the car to be turned on individually	Students identify series and parallel circuits, then use this knowledge to simulate the creation of a parallel circuit with different criteria Direct students to the corresponding Stile X revision notes to complete the question: Summarise the difference between series and parallel circuits by reading the passage and highlighting	As a class, have a discussion to reflect on what they have learnt during this unit especially in regards to sustainable transport Assign **Check-in #3** as homework to be completed before the next lesson	Stile X app: Is there another way to make a circuit? video Stile X Revision notes: Is there another way to make a circuit? Glossary terms: series circuit, parallel circuit

	Lesson name	Learning goals	Preparation required	Ice breaker	Core of lesson	To close	Revision and mastery
Session 17	**Unit review Stile X: Practice test**		Review Key and Challenge Questions from the unit in Analyse Mode to identify areas to revisit with students during the lesson 30 minutes	Introduce students to the practice test section of Stile X and explain how it will help them prepare for the test	Revisit any areas of difficulty as a class or with groups of students	Encourage students to review feedback and model answers from the unit for revision	Study Stile X Revision notes in preparation for **Test: Non-contact forces and electricity** Stile X app: Flash quiz 3
Session 18	**Test: Non-contact forces and electricity**		Ensure each student has access to a device	Seat students appropriately for the test	Supervise students as they complete the test	Fast finishers can complete mindful colouring activities in Stile X	Stile X: Reflection

Lab Guide

Getting ready for Non-contact forces and electricity

This unit is designed to get students using their hands to explore non-contact forces. This means that there are lots of materials that you'll need to make this unit a success. The next few pages contain a summary of the materials we used during testing, links to where you can purchase those same materials and advice on any required material preparation.

To get ready for the unit, we recommend buying the ***Non-contact forces and electricity: Essentials kit*** from the **Stile shop**.

The kit contains the hardest to source components from the unit. This includes:

- coiled copper wire on pre-cut round wooden dowel
- all neodymium magnets

If you don't want to buy the kit, that's okay too. As an alternative, you can source and prepare the materials yourself. In this case, simply follow the instructions on the next few pages of the Lab Guide.

Complete unit material list

Sourcing all of the materials you need can be hard. To make it easier, we've compiled the list below to show you where we purchased the materials we used in our development and testing of the unit.

This equipment is available in the Essentials kit

Equipment	Supplier	Purchase link	Preparation required	Quantity required per group
A4 transparent plastic sheet	Officeworks	**Nobo Plain Paper Copier Transparency Film 20 Pack**		1 sheet
AAA rechargeable batteries	Officeworks	**Energizer Rechargeable AAA Batteries 4 Pack**		1 battery
Bar magnet	Haines	**Bar Magnets, Plastic Cased (pair)**		2 magnets
Blu Tack	Officeworks	**Bostik Blu Tack Removable Adhesive 75g**		1 stick
Borax	Coles	**Bare Essentials Borax Cleaner 500g**	Refer to the *Before class preparation* section of the **Magnetic slime lesson**	1 tablespoon
Compass	Haines	**Compass, plotting (18 mm)**		1 compass
Copper coil (20 SWG) (available in the Essentials kit)	Haines	**Copper wire (bare) 20 SWG - 50g reel ~8.5m**	Refer to the **Appendix**	1 coil
Elmer's school glue	Officeworks	**Elmer's School Glue 946 mL**		100 mL
Insulated bell wire	Haines	**Copper wire (bellwire) - 100 m**	Refer to the *Before class preparation* section of the **Electromagnets** and **Electric motors** lessons	1.5 m
Iron filings	Haines	**Iron filings, fine 500 g**		3 tablespoons
Iron nail	Bunnings	**Paslode 150 x 5.6mm 500g Bullet Head Bright Nails - 16 Pack**		1 nail

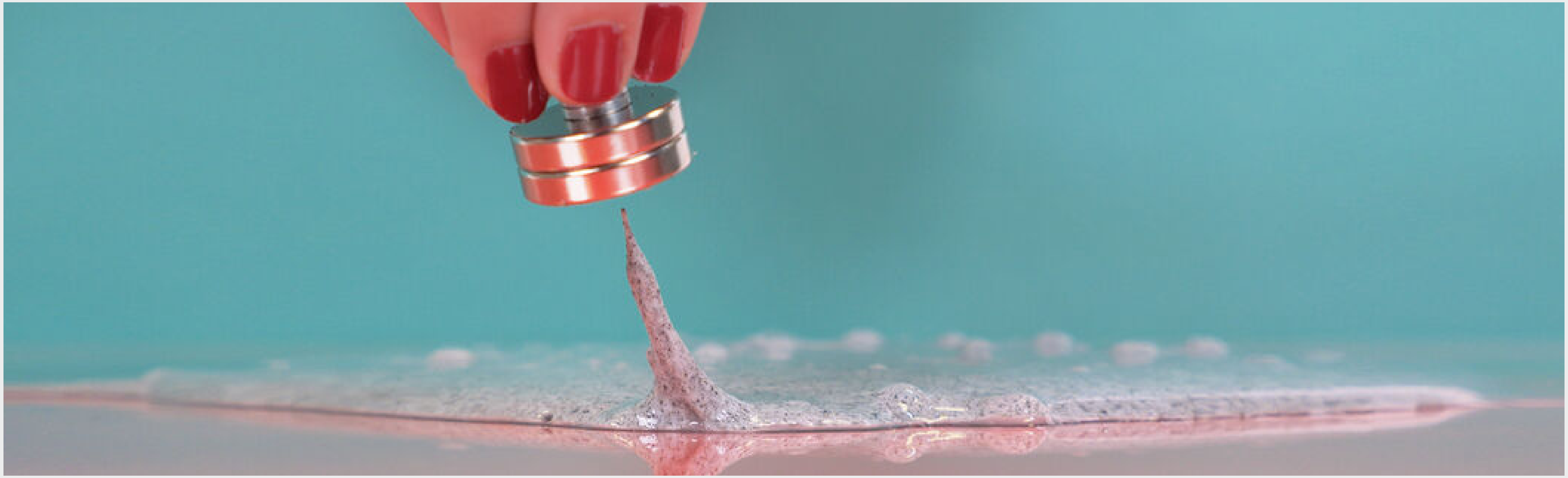
Complete unit material list (cont.)

This equipment is available in the Essentials kit

Equipment	Supplier	Purchase link	Preparation required	Quantity required per group
Neodymium magnet (round)	Aussie Magnets	**12mm x 5mm Disc (Rare Earth) 20 pack**		2 magnets
Neodymium magnet (rectangular)	Aussie Magnets	**25 x 12.5 x 6mm Block (Rare Earth) 10 pack**		2 magnets
Neodymium magnet (square)	Aussie Magnets	**10 x 10 x 10mm Block (Rare Earth) 10 pack**		2 magnets
Paper clips	Officeworks	**50 mm Paper Clips**		15 paper clips
PVC (insulation) tape (Electrical tape)	Bunnings	**18 mm Insulation PVC Tape**		1 piece
PVC pipe	Bunnings	**20mm x 3m Class 12 PVC Pressure Pipes**	Refer to the **Appendix**	2 lengths
Rulers	Officeworks	**Recycled Plastic Ruler 30 cm Clear**		1 ruler
Staples	Officeworks	**Staples - 5000 pack**	Refer to the *Before class preparation* section of the **Electromagnets** lesson	1 pack
Wooden dowel (square)	Bunnings	**12 mm x 12 mm 1.2 Pine DAR**	Refer to the **Appendix**	2 lengths
Wooden dowel (round)	Bunnings	**12.5 mm 1.2 m Dowel Pine Clear**	Refer to the **Appendix**	1 length

OPEN-ENDED INVESTIGATION

Magnetic slime: Can you lift slime without touching it?



Watch the demo video

stileapp.com/go/ncfslimevideo

Activity purpose: Explore the attractive forces of magnetism through a hands-on investigation.

45 minutes	Lesson: **stileapp.com/go/magneticslime**
2–4 students per group	RiskAssess: **stileapp.com/go/ramagneticslime**

Materials

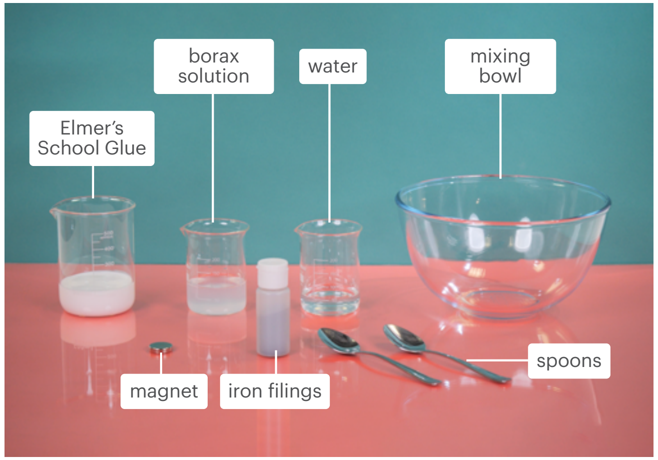
Each group of students will need:

LEVEL 1:

- 100 mL Elmer's School Glue
- mixing bowl
- spoons
- 50 mL water
- 1 tablespoon borax solution
- 1 tablespoon of iron filings
- neodymium magnet (round)

LEVEL 2:

- additional neodymium magnets (2–3)
- additional iron filings (2–3 tablespoons)
- rulers
- timers
- *optional: 1 tablespoon of conditioner*



Before class preparation

This activity is run in two parts, or levels. Keep the materials required for Level 1 and Level 2 separate. Do not give students all materials for both challenges at the start of the lesson.

5 min: Prepare the borax solution in advance. The borax solution can be made with one tablespoon of borax (or washing powder with borax in the ingredients) mixed into 100 mL of water.

Optional: A tablespoon of conditioner can be mixed into the slime to make it less sticky.

Tips and tricks

Things we learned from testing the lab ourselves

The magnetic slime doesn't store well after being made. The top layer oxidises, and the viscosity increases, making it challenging to work with.

The slime that each group makes in Level 1 can be divided into smaller portions once it is made. This allows students to conduct investigations in smaller groups.

The slime students make in Level 1 is intentionally underwhelming. Don't let students be disheartened. To build engagement in the activity, create some well-magnetised slime immediately before class. Use your slime as a demonstration of what students should be trying to work towards.

Disposal of materials

Ensure slime is disposed of in a rubbish bin and not down the sink.

Method

LEVEL 1:

1. Pour 100 mL of glue into a mixing bowl.
2. Mix in 50 mL of water.
3. Slowly drizzle the borax solution into your mixture. Stir with a spoon as you go. The mixture should start to thicken.
4. Use your hands to grab the slime out of the bowl. The slime should feel likea runny jelly.
5. Add the iron filings using a new, dry tablespoon. Knead the slime with your hands to ensure an even distribution of iron filings.
6. Move a magnet close to your slime and see if part of the slime lifts towards the magnet.

LEVEL 2:

In Level 2, students devise their own testable question to explore the variables in the magnetic slime. There are two recommended ways that students go about this investigation.

- Option 1: Add more iron filings to the slime.
- Option 2: Use more magnets.

Both methods should provide students with valid results to discuss.

Final outcome

What you can expect to see at the end

Student results will vary depending on the viscosity of their slime, the amount of iron filings and the number of magnets. Regardless of the method students use, they are not expected to observe much movement of slime from Level 1. As students add magnets or iron filings in Level 2, students are expected to see a steady increase in the interaction between the slime and the magnets.

Students should be able to lift a trail of slime up to 4 cm off the table without touching it by the end of Level 2.

Level 1:

1 x magnet

1 tablespoon iron filings

little or no interaction

Level 2:

3 x magnet

1 tablespoon iron filings

1 x magnet

3 tablespoon iron filings

strong interaction between magnet and slime

PRACTICAL ACTIVITY

Electrostatic forces: Are magnets the only solution?

Watch the demo video

stileapp.com/go/ncfelectrostaticvideo

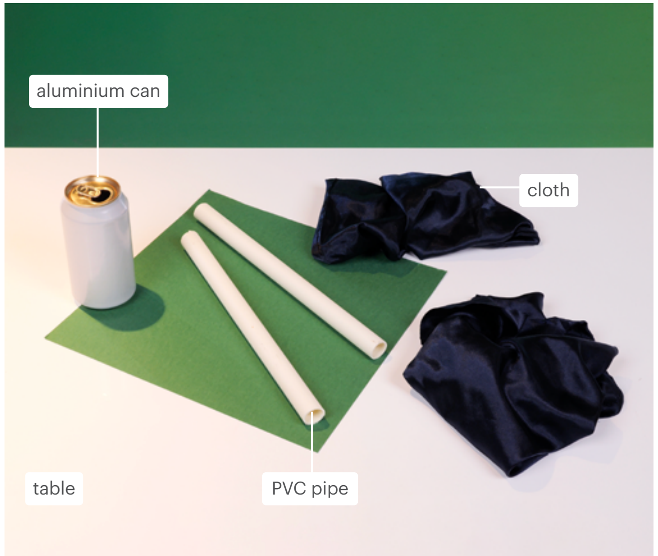
Activity purpose: Explore the factors that increase the strength of electrostatic forces through a fun competition.

45 minutes	Lesson: **stileapp.com/go/electrostaticforces**
2–3 students per group	RiskAssess: **stileapp.com/go/raelectrostaticforces**

Materials

Each group of students will need:

- 1 aluminium can
- 2 x 30 cm long PVC pipe
- two cloths
- flat and clear table to roll can along



Before class preparation

5 min: Tables should be arranged lengthways so that students can roll their can down the table.

To source the aluminium cans required for this activity, ask students to bring cans and cloths from home into class.

Tips and tricks

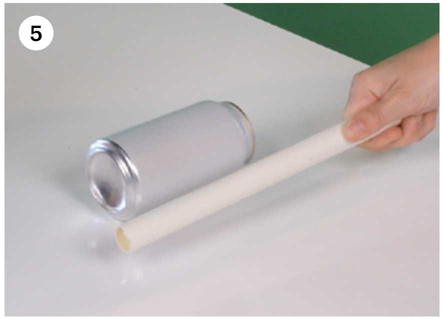
Things we learned from testing the lab ourselves
There are lots of materials that work well with this activity. If you have the materials, encourage students to try different types of cloth to see their effect.

Students can also use their own clothing to charge their PVC pipes. Wool sweaters work particularly well.

If you have time, consider turning this activity into a friendly knockout competition. As each round of the competition draws to a close, ask the winners to explain the strategy they used to maximise their electrostatic forces of attraction.

Method

1. Clear your desk completely.
2. Take a PVC pipe and cloth each.
3. Place your aluminium can in the middle of the desk and stand at either of the long ends of the table.
4. Rub the PVC pipe vigorously on your cloth five times.
5. When your teacher says “GO!” try to move the can off your end of the desk.
6. Continue recharging your PVC pipe and pulling the can until one person wins by pulling it off their table edge.

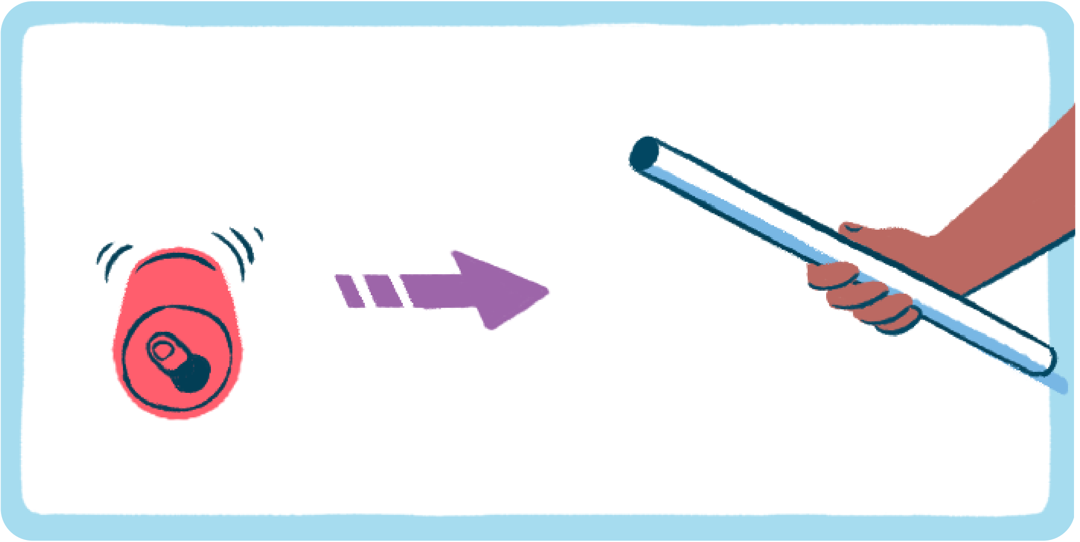


Final outcome

What you can expect to see at the end
As students bring their charged PVC pipe towards the aluminium cans, the can will be attracted towards them. This is because of the overall negative charge present on the PVC pipe.

There are two ways that students can increase the force of attraction between the PVC pipe and the aluminium can.

1. Increase the charge on the PVC pipe. This can be done by rubbing the PVC pipe with the cloth more vigorously and for a longer time.
2. Bring the PVC pipe closer to the aluminium can.



OPEN-ENDED INVESTIGATION

Magnetic accelerators: Can you boost your transport system?

Watch the demo video

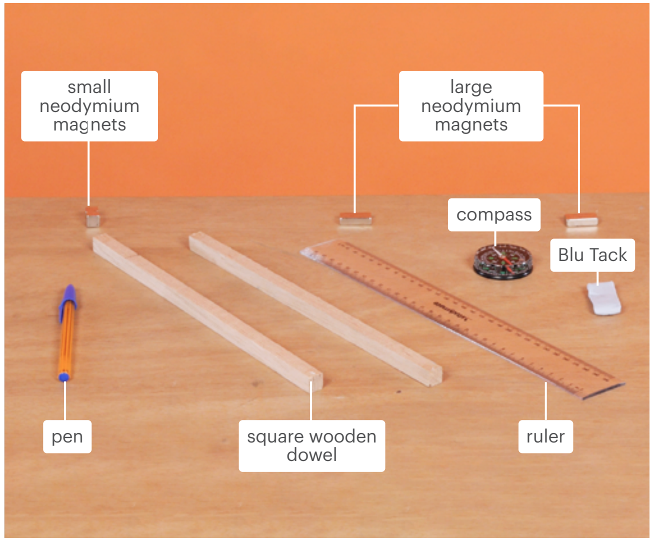
stileapp.com/go/ncfacceleratorvideo

Activity purpose: Use data to determine the best design of a magnetic accelerator.

45 minutes	Lesson: stileapp.com/go/magneticaccelerator
2–4 students per group	RiskAssess: stileapp.com/go/ramagneticaccelerator

Materials

Each group of students will need:
- 2 large rectangular neodymium magnets
- 2 small square neodymium magnets
- 2 pieces of square wooden dowel (30 cm long)
- a clear plastic ruler
- Blu Tack
- pencil or pen
- compass



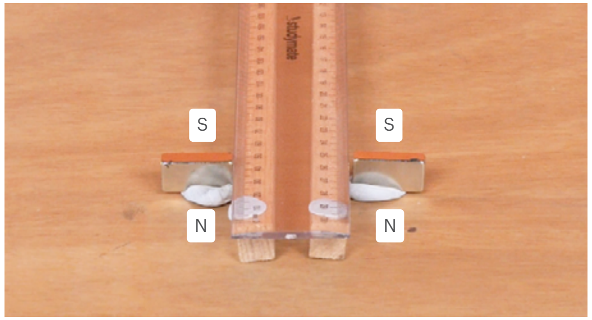
Before class preparation

Depending on where the square wooden dowel are sourced from, these may need to be cut to length before class.

Each group will need two square wooden dowel, each approximately 30 cm long.

Tips and tricks

Things we learned from testing the lab ourselves
The magnetic accelerator is a great way to "wow" students. When showing students how to put it together, explain that the space between the wooden dowel must be large enough for the small magnets to pass through, but not wide enough for them to turn.



The magnetic accelerators can fire the small magnets up to 50 cm. It's best to set up the magnetic accelerators on long tables, or on the floor, to accommodate for this.

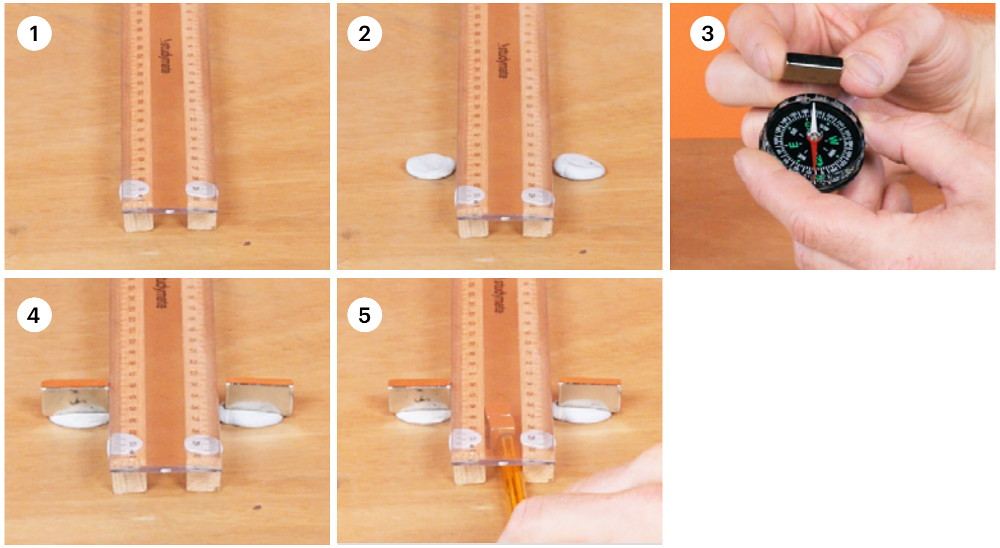
Note that when placing the magnets on the outside of the accelerator, the orientation of the poles should be parallel to the accelerator. This means that the poles should face towards and away from the entry of the accelerator, rather than inwards.

To make it easier to place the small magnets inside the accelerator, place the large magnets around 8 cm away from the entry point on the accelerator chute.

Method

1. Blu-Tack the two pieces of square wooden dowel to the ruler. Make sure the space between the two pieces of wooden dowel is large enough for the small magnet to pass through.
2. Add two pieces of Blu Tack to the table on the outside of the wooden dowel. This is where the large neodymium magnets will be placed.
3. Use a compass to determine the poles of the large neodymium magnets.
4. Place the neodymium magnets on the pieces of Blu Tack, ensuring the poles of the magnet run parallel to the accelerator chute.
5. Place the small magnet in one end and use a pencil to push the magnet into the shoot. The magnet should travel by itself after a few centimetres.

Note: Keeping track of the poles of the magnets can be tricky. To help, direct students to add a small piece of Blu Tack to the north pole of each magnet. This will help them quickly identify each magnet's orientation.



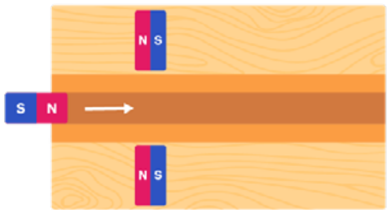
Final outcome

What you can expect to see at the end
Different orientations of magnets in the magnetic accelerator will produce different results. The results below were gathered using an average of three trials, following the method explained in the lesson.

There are more configurations than those shown below. The inverse of any configuration shown below should produce a similar result. For example, swapping the poles of all magnets in Design 2 should produce an average distance travelled of around 47.2 cm.

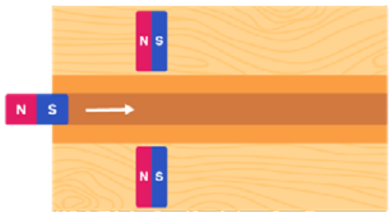
These tests were conducted on a wooden table. Smooth tables should produce higher average distances than rough tables.

Design 1



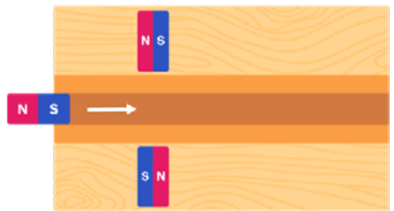
Average distance travelled: 15.9 cm

Design 2



Average distance travelled: 47.2 cm

Design 3



Average distance travelled: 4.9 cm

PRACTICAL ACTIVITY

Magnetic fields: How do magnets interact?

Watch the demo video

stileapp.com/go/ncfmagneticfieldsvideo

Activity purpose: Investigate magnetic fields in order to visualise the forces at play in magnetic interactions.

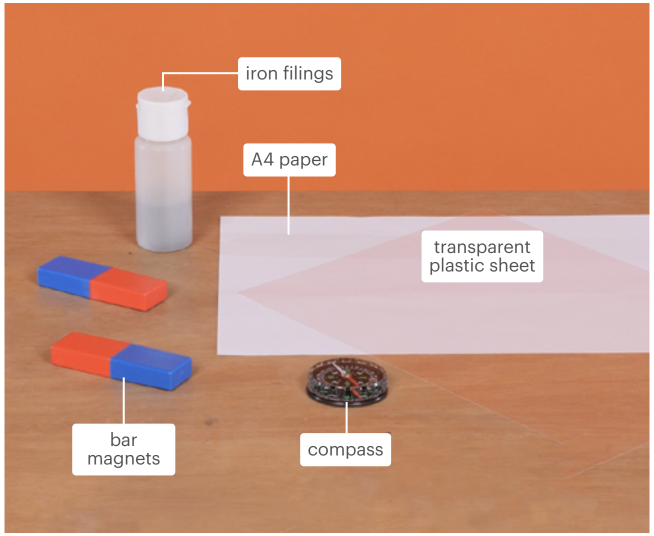
45 minutes	Lesson: **stileapp.com/go/mappingmagneticfields**
2–3 students per group	RiskAssess: **stileapp.com/go/ramappingmagneticfields**

Materials

Each group of students will need:

- 2 bar magnets
- 2 pieces of blank paper (A4)
- 1 transparent plastic sheet (A4)
- 1 tablespoon of iron filings
- compass
- pencil

Note: Students will need to re-use their iron filings, so care should be taken when using them and putting them back in their containers.



Before class preparation

Dividing materials into quantities needed for each group will save time when setting up this activity.

Tips and tricks

Things we learned from testing the lab ourselves

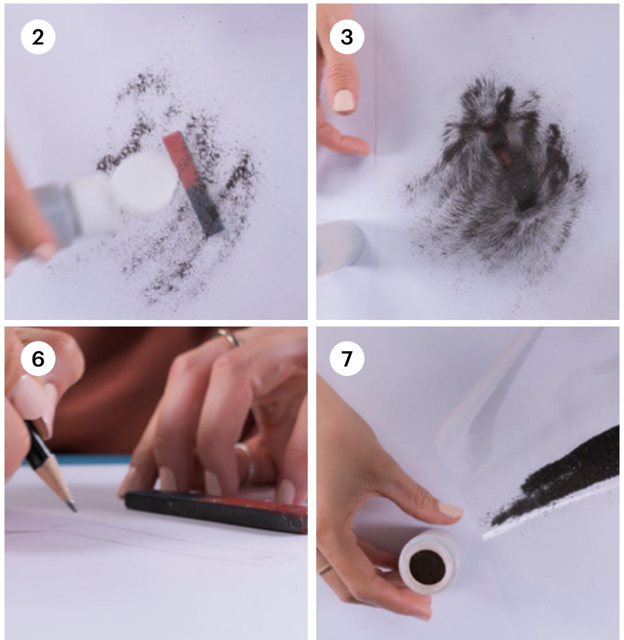
Getting a clear image of magnetic field lines can be difficult. If students are struggling, ensure they have an even distribution of iron filings across the transparent sheet. Lightly tapping on the sides of the sheet while the magnet is below should help spread out the iron filings.

When moving the iron filings away from the magnet so that they can be traced, lift the transparent sheet up, directly away from the magnet. This will prevent the iron filings from being dragged to one side, disturbing the pattern.

Method

PART 1A

1. Take the clear sheet and hold it over the magnet. It should be about 10 cm above the table.
2. Sprinkle some iron filings onto the plastic sheet to cover a 15 x 15 cm square.
3. Place the sheet over the top of the magnet so that it's touching. Gently tap the sides of the sheet, and the magnetic filings will begin to move.
4. To reset the iron filings, take the clear sheet away from the magnet and tap the sides gently.
5. Once you have created a pattern, lift the clear sheet straight up and move it to the side to observe the pattern.
6. On your white sheet of paper, draw the magnet's position and which pole is which. Draw the pattern you see onto the sheet of paper using single lines.
7. Place your iron filings back into the container.



Method

PART 1B

1. Place the magnet back onto the diagram on your white sheet of paper. Make sure to match the magnet's poles with the poles that you have labelled on the diagram.
2. Place a compass on five spots on your diagram. Each spot should be on a line of the drawn pattern.
3. Using your marker, draw an arrow in the direction the red needle of your compass points at each spot.

PART 2

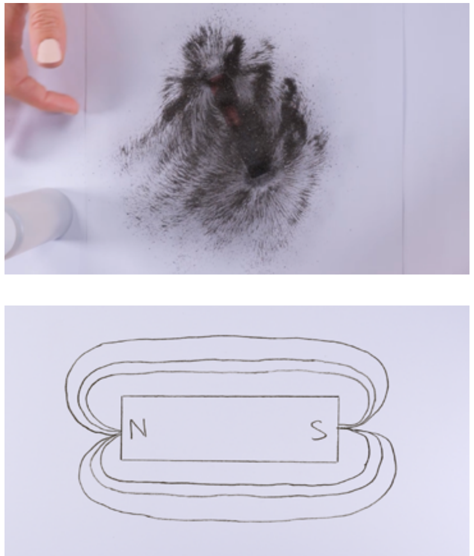
1. Sprinkle your iron filings on the plastic sheet and lift the sheet gently over two magnets.
2. Use the two magnets to investigate what happens to the magnetic fields as you put like poles and opposite poles together.
3. Create a pattern of your magnets attracting and repelling.
4. Sketch a drawing of both patterns.
5. Gently bend the plastic sheet to gather the iron filings and put them back in their container.

Final outcome

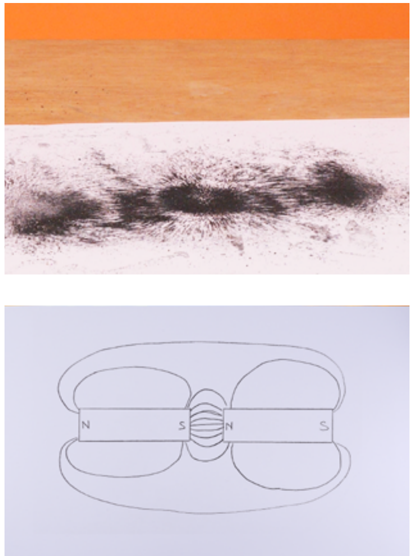
What you can expect to see at the end
The patterns students produce will vary depending on the distribution of iron filings on the transparent paper.

The expected patterns students should observe in Part 1 and Part 2 are:

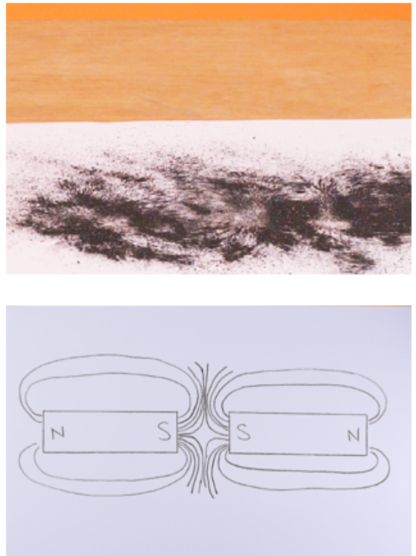
PART 1



PART 2 – Attracting



PART 2 – Repelling



PRACTICAL ACTIVITY

Electromagnetic trains: Can magnetism keep our train moving?

Watch the demo video

stileapp.com/go/ncftrainsvideo

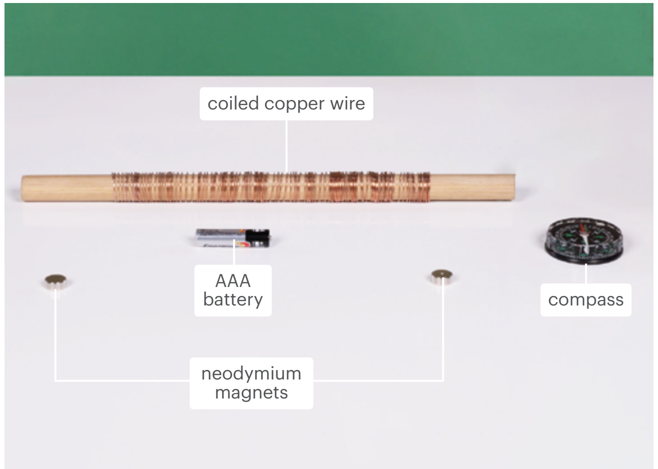
Activity purpose: Students create an electromagnetic train to explore electromagnetic forces.

45 minutes	Lesson: **stileapp.com/go/electromagnetictrain**
2–4 students per group	RiskAssess: **stileapp.com/go/raelectromagnetictrain**

Materials

Each group of students will need:
- AAA battery
- coiled copper wire
- two cylindrical neodymium magnets
- compass

Note: Copper coil of other wire gauges can be used. Thinner gauge wire is more likely to deform during testing. We recommend no thinner than 22 SWG for this activity.



Before class preparation

If you have time, we recommend coiling the copper wire before class.Alternatively, you can show students the how-to video for coiling copper wire, and have them coil it themselves.

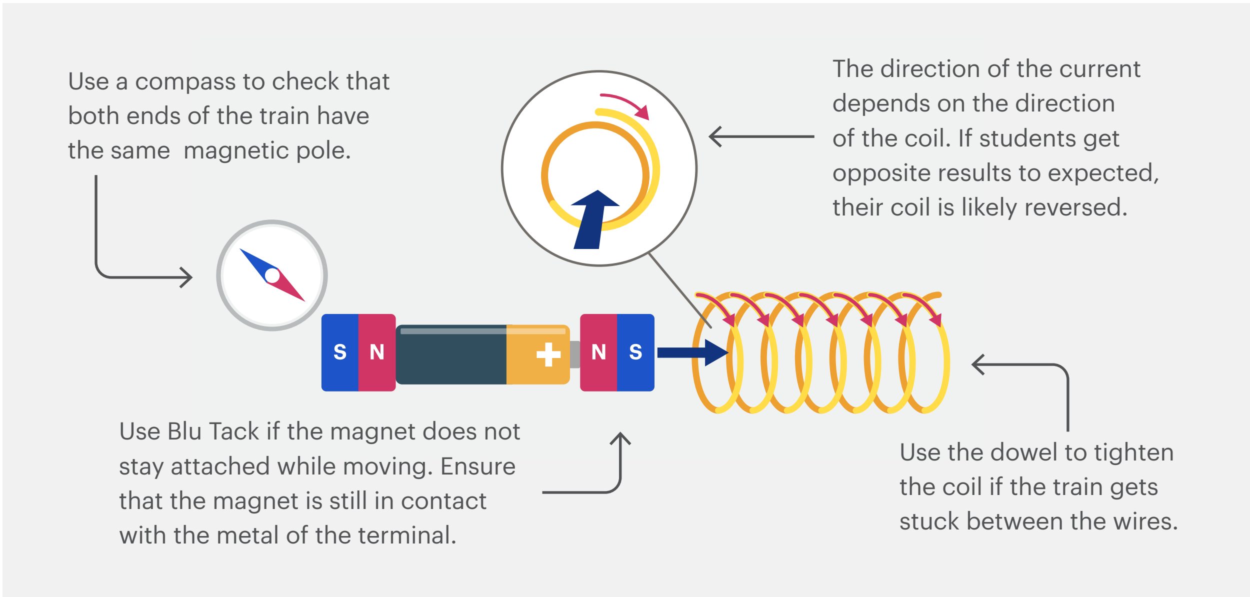
Coiling the copper wire will take around 5 minutes per coil.

Before class, check that all batteries are fully charged.

Tips and tricks

Things we learned from testing the lab ourselves
Getting a clear image of magnetic field lines can be difficult. If students are struggling, ensure they have an even distribution of iron filings across the transparent sheet. Lightly tapping on the sides of the sheet while the magnet is below should help spread out the iron filings.

When moving the iron filings away from the magnet so that they can be traced, lift the transparent sheet up, directly away from the magnet. This will prevent the iron filings from being dragged to one side, disturbing the pattern.



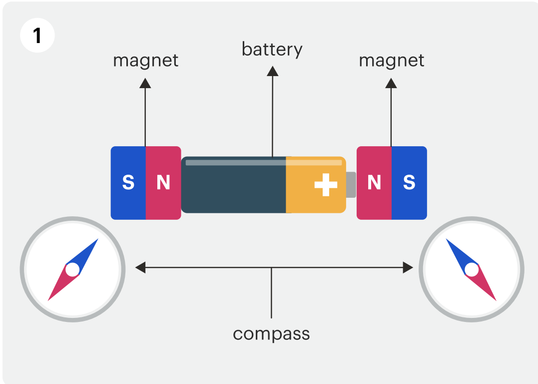
Method

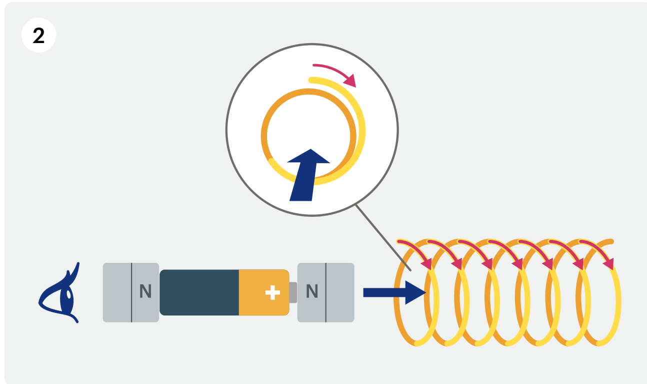
1. Attach the magnets to the battery so that the north pole is facing inwards, as shown in the diagram.

   Hint: Use your compass to check that each end of your train is a south pole.

2. Arrange your copper tunnel so that the wire at the entrance of your tunnel coils clockwise (to the right). Setting up your coils the same way makes it easier to compare results.

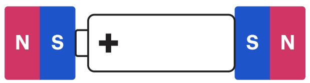
3. Record your observations of your train.





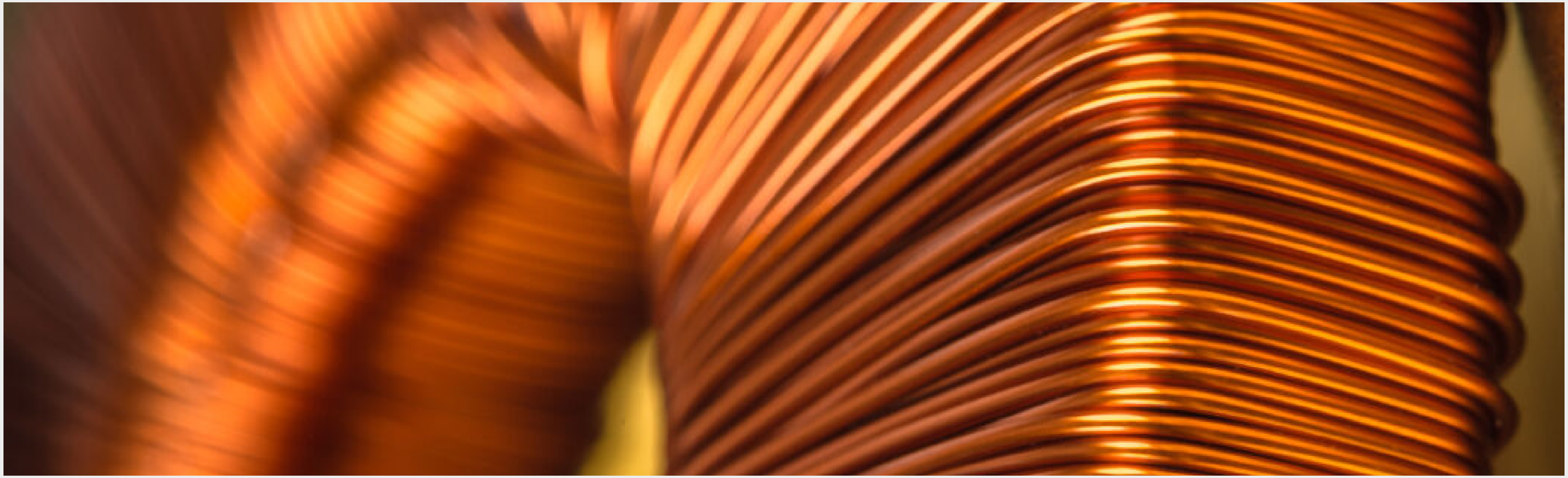
Final outcome

What you can expect to see at the end
The table below summarises the expected outcome for the first activity.

Train	Did the train move through the clockwise coil?	Type of force observed
	Yes	Attraction
	No	Repulsion
	No	Repulsion
	Yes	Attraction

OPEN-ENDED INVESTIGATION

Electromagnets: How can we make an electromagnet?



Watch the demo video

stileapp.com/go/ncfelectromagnetvideo

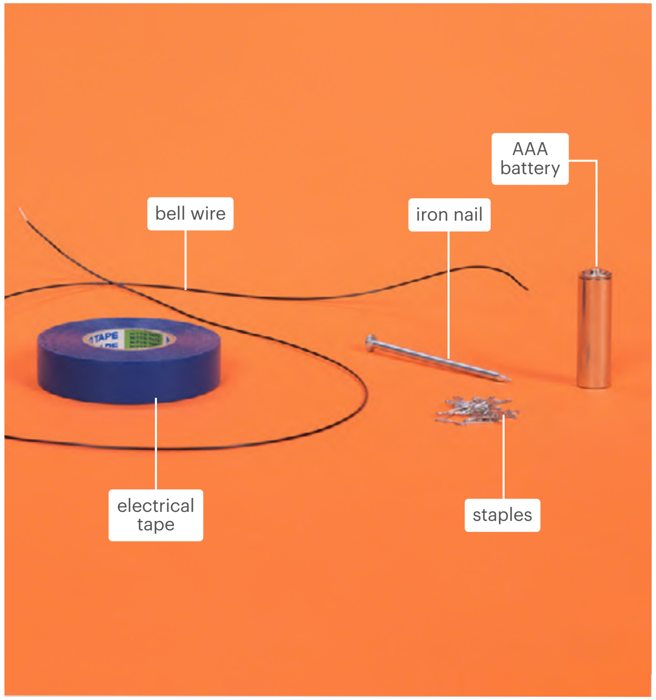
Activity purpose: Students investigate factors that affect the strength of an electromagnet.

45 minutes	Lesson: **stileapp.com/go/makingelectromagnet**
2–3 students per group	RiskAssess: **stileapp.com/go/ramakingelectromagnet**

Materials

Each group of students will need:
- 80 cm of insulated bell wire (exposed ends)
- AAA battery
- iron nail
- two pieces of electrical tape
- staples

Note: The staples need to be separated before testing.



Before class preparation

10 min: The first time you run this activity, you'll need to cut the insulated bell wire into 80 cm lengths. These lengths can be reused once they have been cut.

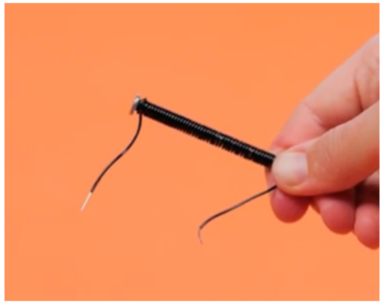
Ensure the ends of the wire (around 1 cm) are stripped to allow for contact with the battery.

Before class, do a quick test of the electromagnet using the materials you have at hand. Identify the minimum number of coils needed to see consistent results. This will help when identifying problems with students' electromagnets.

Tips and tricks

Things we learned from testing the lab ourselves

If students are struggling to get their electromagnet to work, check that their bell wire is tightly coiledaround the wire. The tighter the coil, the more effective their electromagnet will be.



If they still aren't seeing results, check that the stripped ends of the bell wire are securely attached to the terminals of the battery.

Note that it's important students drop the nail between their tests. This demagnetises the nail, ensuring that each of their following tests are fair.

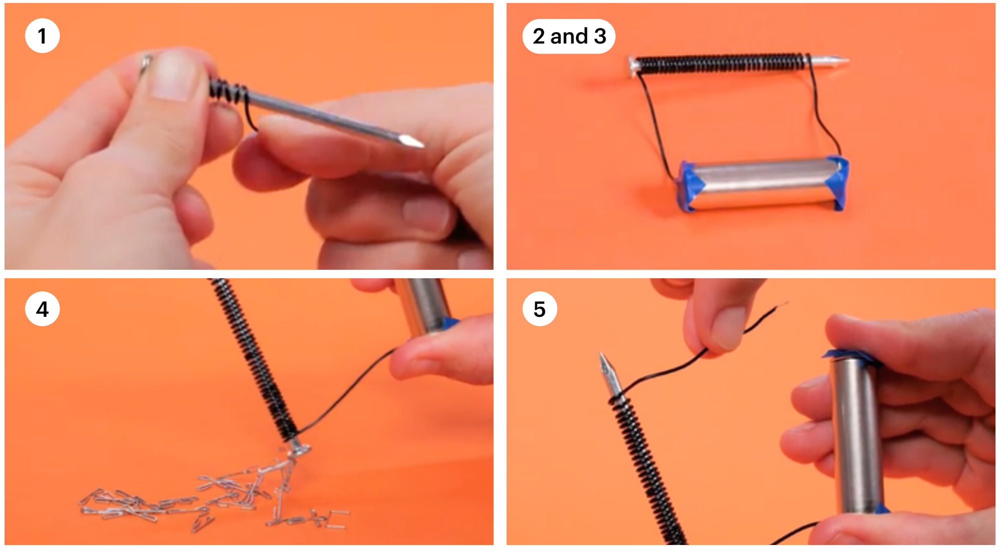
Method

1. Wind the wire tightly around the nail.

2. Use electrical tape to connect one end of the wire to the battery's positive terminal.

3. Place the other end of the wire on a piece of electrical tape.

4. Turn on your electromagnet:
   - Touch the battery's negative terminal to the wire on the electrical tape.
   - Stick the electrical tape onto the battery. Make sure to cover any exposed parts of the wire.
5. Turn off your electromagnet:
   - Disconnect the wire from the negative terminal of your battery when you have finished testing
6. Demagnetise the electromagnet between tests by gently dropping the nail on the table.



Final outcome

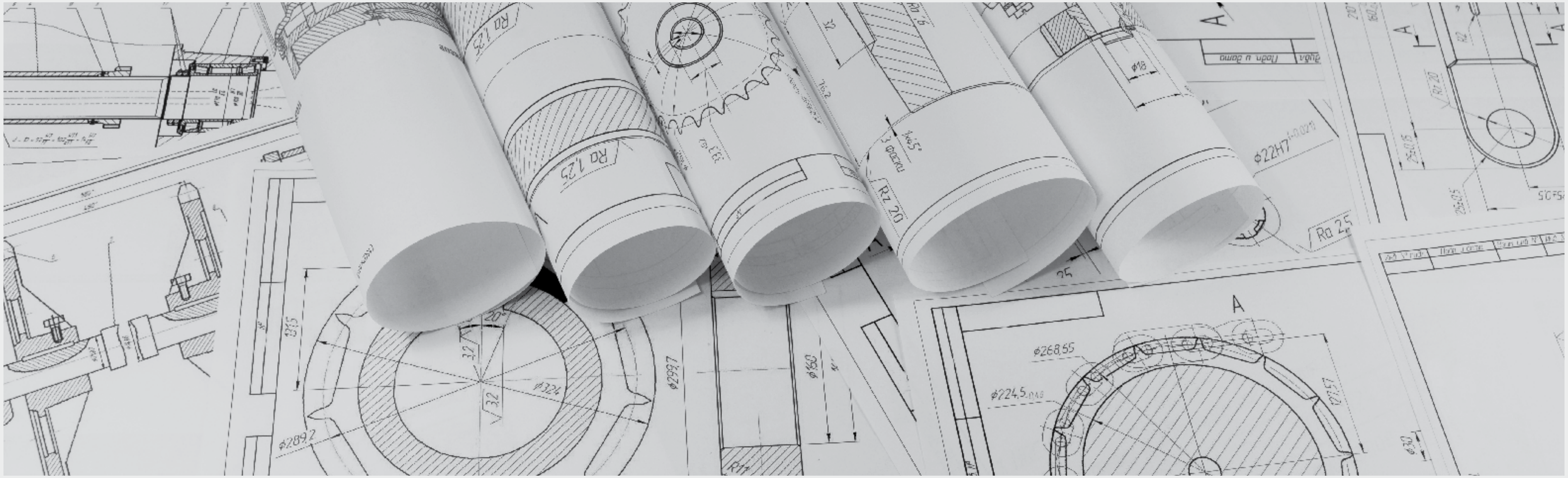
What you can expect to see at the end

The number of items the electromagnet picks up depends on a number of factors. These include the number of coils, the mass of the items, the connection between the battery terminals and the wire and the charge of the battery. The table below shows what an expected outcome may be for different numbers of coils.
The staples used in the test were individually separated.

Number of coils	Staples	Paper clips
15	8	2
20	11	3
25	13	4
30	18	6

ENGINEERING CHALLENGE

Engineering challenge: Testing your prototype



Watch the demo video

stileapp.com/go/ncfengchallengevideo

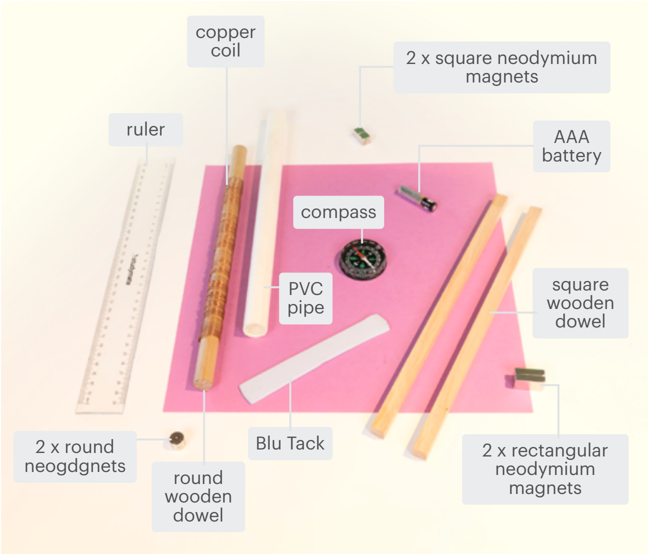
Activity purpose: To test and evaluate one component of the overall transport solution design.

90 minutes	Lesson: **stileapp.com/go/creatingatransportsolution**
3–4 students per group	RiskAssess: **stileapp.com/go/racreatingatransportsolution**

Materials

Students can use any combination of materials they used in previous lessons. This may include:

- AAA battery
- copper coil
- two round neodymium magnets
- two rectangular neodymium magnets
- two square neodymium magnets
- square wooden dowel
- round wooden dowel
- Blu Tack
- compass
- ruler



Before class preparation

30 min: At the end of the previous lesson, students will have created a list of materials they need to build their prototype. Review this list of materials to ensure that there are enough resources for each group.

Tips and tricks

Things we learned from testing the lab ourselves

This is a complex engineering challenge. As a result, it may be helpful to provide some scaffolding for students as they tackle the task.

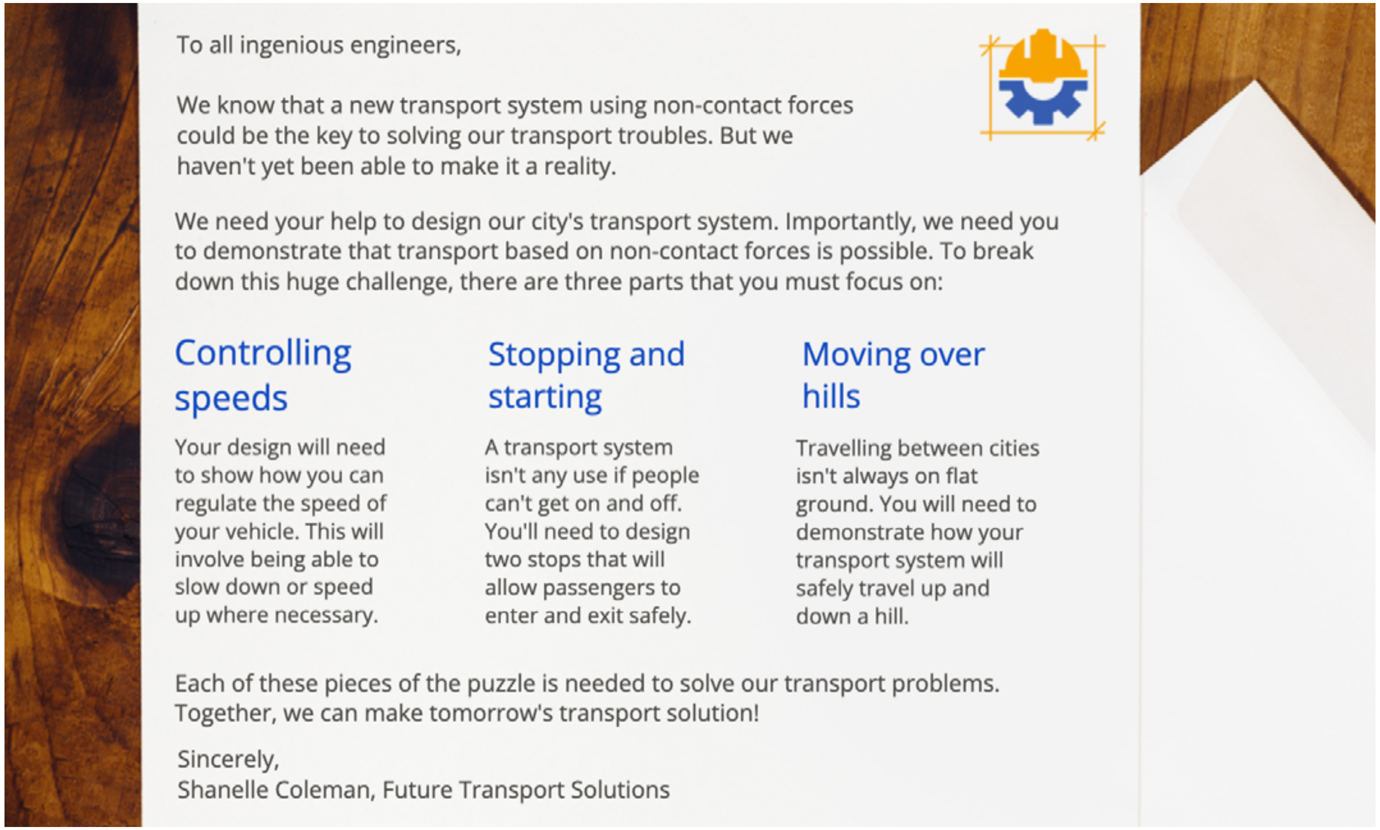
If students are unsure of where to start, we've provided a set of examples for how students might attempt each part of the design brief.

Before students start on their prototypes, it's worth emphasising a few key points:

1. Focus on one element of the overall design. They don't need to build a prototype that meets all criteria, just one of the three listed in the design brief.
2. Use components from the practical activities they've done previously in the unit to support their work.
3. Their model doesn't need to be perfect at the end of the lesson. The goal is to describe how this could work, using evidence they gather throughout the engineering challenge.

Note that all of the examples we provide use the electromagnetic train as a starting point. We've found that this is a useful model to begin with, and then modify, based upon which criteria students want to meet.

The design brief



To all ingenious engineers,

We know that a new transport system using non-contact forces could be the key to solving our transport troubles. But we haven't yet been able to make it a reality.

We need your help to design our city's transport system. Importantly, we need you to demonstrate that transport based on non-contact forces is possible. To break down this huge challenge, there are three parts that you must focus on:

Controlling speeds

Your design will need to show how you can regulate the speed of your vehicle. This will involve being able to slow down or speed up where necessary.

Stopping and starting

A transport system isn't any use if people can't get on and off. You'll need to design two stops that will allow passengers to enter and exit safely.

Moving over hills

Travelling between cities isn't always on flat ground. You will need to demonstrate how your transport system will safely travel up and down a hill.

Each of these pieces of the puzzle is needed to solve our transport problems. Together, we can make tomorrow's transport solution!

Sincerely,
Shanelle Coleman, Future Transport Solutions

Emphasising the engineering process

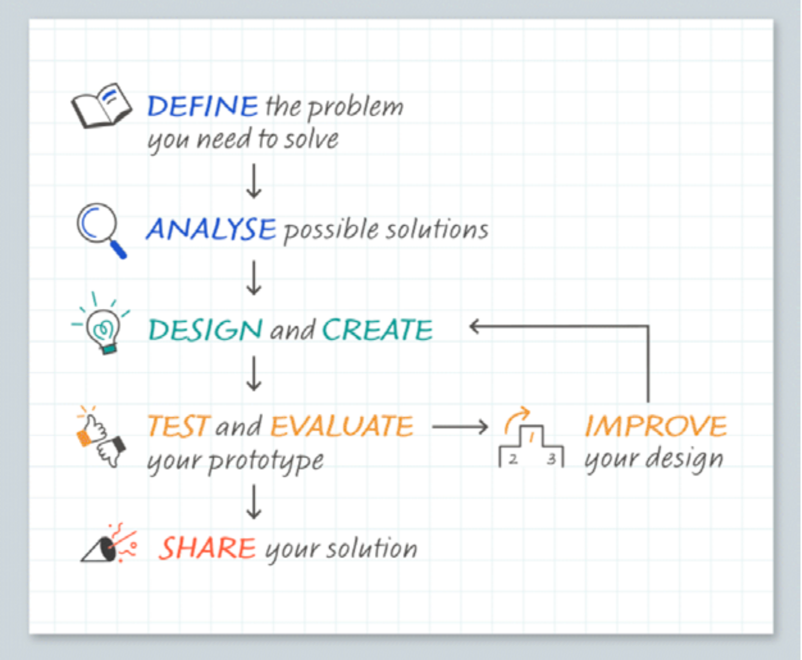
The engineering challenge involves a number of complex interactions. Explaining the forces that propel the electromagnetic train, for example, is well above the level students are expected to meet. As a result, the focus of the engineering challenge should be first and foremost on the engineering process.

To help students engage with the engineering process, encourage them to follow the same steps as appear in the rubric at the end of the engineering challenge.

STEP 1: DEFINE
This is a complex engineering challenge. As a result, it may be helpful to provide some scaffolding for students as they tackle the task.

STEP 2: DESIGN
Draw a design that could solve the problem. Explain how it could work. Think about how experiments and interactions they've observed throughout the unit to this point could provide clues as to where to start.

Note: It can help to keep it simple. Many problems can be solved by considering how the attraction and repulsion of additional magnets could change the motion of the train.



STEP 3: CREATE AND TEST
Build the design and see if it works. It isn't expected to work the first time you try. That's why the engineering process includes the evaluate and improve steps.

STEP 4: EVALUATE
Encourage students to write down what happened. Did it work as expected? Did anything move in unexpected ways? How far did the train travel? This is the time to take measurements and write down notes.

STEP 5: IMPROVE
This step takes up most of the engineering challenge. This is the chance to make changes to the design and see how it affects its performance. Encourage students to make a small change, re-test, re-evaluate and then improve upon it once more. Many cycles of improvement will provide students with lots to talk about at the end.

STEP 6: SHARE
Sharing the outcome of the engineering challenge isn't just about success and failure, it's about what was learned along the way. Encourage students to explain what they did to refine how their prototype worked. Were they successful? If they weren't successful, why not?

Note that, through this whole process, explaining how the train functions is a small piece of the puzzle. The more significant part is considering how simple interactions of attraction and repulsion can be manipulated to meet a design criteria. Students interested in extension can go into greater depth about how the train functions, but a successful engineering solution doesn't rely upon this explanation.

Final outcome

There are lots of possible solutions to the engineering challenge, here are a few examples we came up with during testing

CRITERIA 1:
Controlling speed

The ability to control speeds can be hard to demonstrate, but students should be able to justify what they could do to make it possible. Gathering data on the speed of a train can also be challenging. We recommend recording the train using a phone or computer. This will allow students to count the number of frames it takes for a train to pass through the loop. This provides a more accurate measure of time than using a stopwatch.

There are many ways students could demonstrate how the speed of the train can be changed. Three examples include:
- increasing or decreasing the spacing of the coils in the electromagnetic train track
- changing the mass of the battery
- altering the strength of the magnets

CRITERIA 2:
Stopping and starting

Although stopping and starting might seem like an easy criteria to meet, it may require students to think creatively about what this would look like in the real world. Encourage students to think about supporting structures beyond the track itself that will help achieve the goal.

Two examples of what students might use to stop and start their train include:
- introducing a magnetic barrier to stop the train, and removing the barrier to get the train moving again
- creating a gap in the tracks to stop the train, although students will need to explain how they'll get the train back onto the tracks and moving again

CRITERIA 3:
Moving over hills

While students might be able to get their train up a small incline without many modifications, they're likely to run into two problems:
1. If the incline of the hill is too great, their train doesn't have enough of a driving force to make it up.
2. As the train comes down the other side of a hill, it doesn't maintain a constant speed.

To solve these problems, there are some common approaches students might want to employ. Three examples include:
- using a magnetic accelerator to boost the train going up a hill
- using a second train moving in the same direction to help drive a train up a hill
- using a second train moving in the opposite direction to slow a train moving down a hill

Note that securing the train to the track on an incline can be a challenge in itself. One option is to place the train coil inside the PVC pipe. This gives it some rigidity, making it easier to hold the track in place.

Troubleshooting

Some tricky areas in the engineering challenge that may require additional support

Before students begin working on their prototype, ensure they have a strong understanding of which criteria they want to meet, as well as how their design should work. Understanding how the prototype should meet the criterion will help students know what to look for and measure during the testing phase.

Encourage students to run repeated tests and document their results. Having sufficient data will help students justify how the prototype works towards a solution, even if it doesn't fully perform as expected.

Remind students that they should be continually adjusting their prototypes throughout the engineering challenge. Encourage them to document small changes, and reflect upon the impact of these changes on the performance of the prototype.

Engineering alternative: Planning, not prototyping

If using all of the suggested materials in your engineering challenge isn't feasible, use this engineering alternative

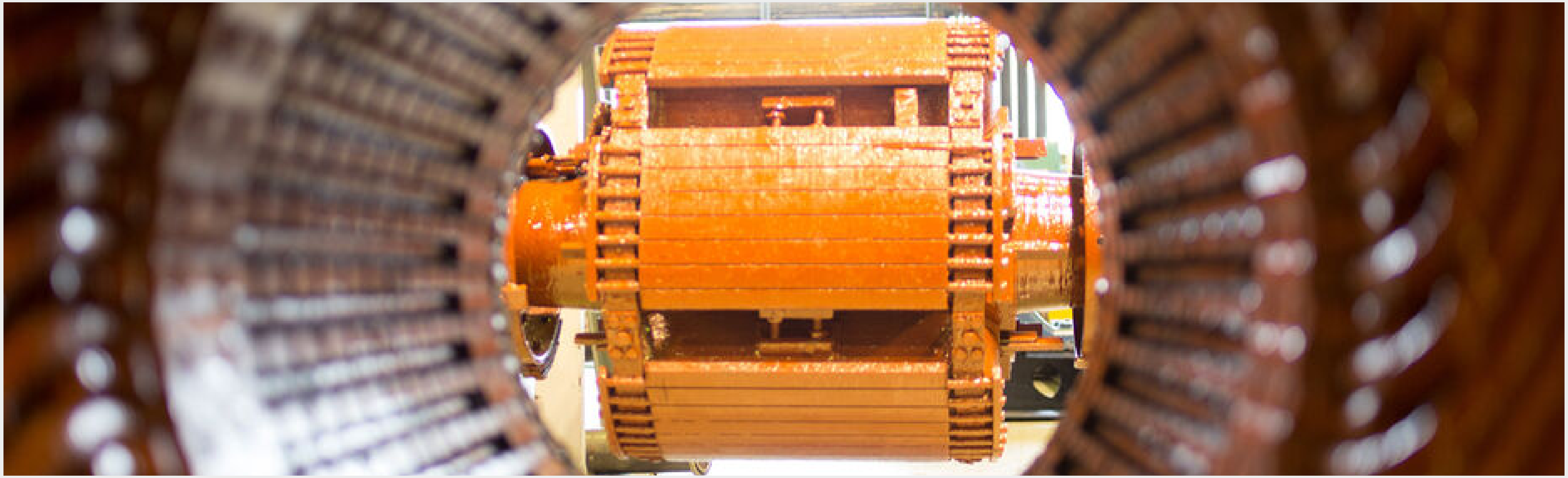
Engineering challenges such as these are resource intensive, but they don't need to be. This engineering challenge can easily be modified to focus on the research and planning phase of the engineering process rather than testing and evaluating a prototype.

If this alternative would work better for you or your students, we suggest the following changes in how the engineering challenge is delivered:

1. When introducing the design brief, explain that students will need to justify how they will meet all of the criteria, not just one.
2. In the second engineering lesson, rather than developing a prototype for one aspect of the transport solution, direct students to create an annotated design for each element. Emphasise that they must show all of the non-contact forces at play and explain how they would be expected to function in the real world.
3. When communicating their solutions to their peers, encourage groups to compare all aspects of their solutions. Identify similarities and differences in how each criterion was addressed and how these different solutions could be combined.

PRACTICAL ACTIVITY

Electric motors: How does an electric car work?



Watch the demo video

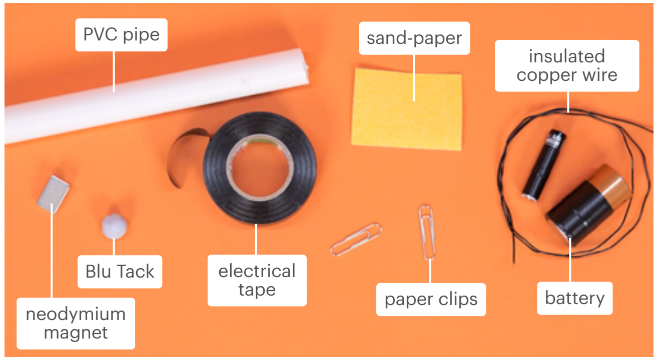
stileapp.com/go/ncfelectricmotorvideo

Activity purpose: Explore the components of an electric motor to evaluate how it works.

45 minutes	Lesson: **stileapp.com/go/makinganelectricmotor**
2–4 students per group	RiskAssess: **stileapp.com/go/ramakinganelectricmotor**

Materials

Each group of students will need:
- AAA battery
- neodymium magnet
- 65 cm insulated copper wire
- 2 paper clips
- sandpaper
- electrical tape
- PVC pipe, or another object with a 2–2.5 cm diameter
- Blu Tack



Before class preparation

At the end of the previous lesson, students will have created a list of materials they need to build their prototype.
5 min: Review this list of materials to ensure that there are enough resources for each group.

Tips and tricks

Things we learned from testing the lab ourselves
This is a complex engineering challenge. As a result, it may be helpful to provide some scaffolding for students as they tackle the task.

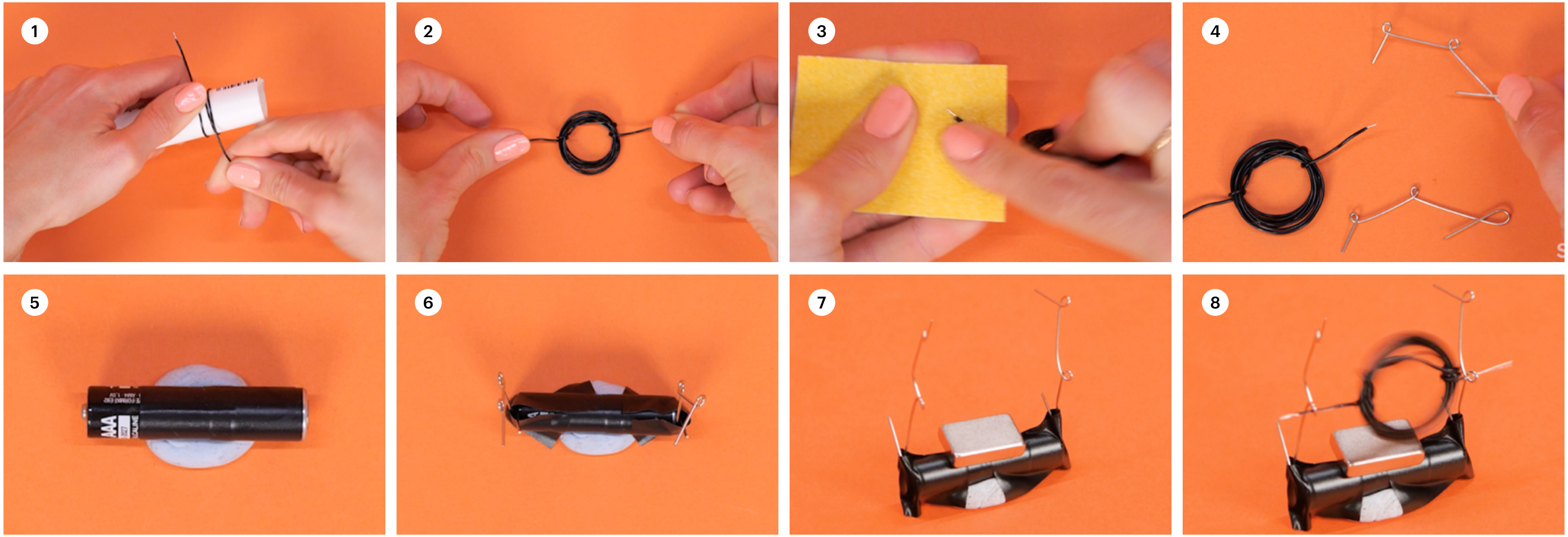
If students are unsure of where to start, we've provided a set of examples for how students might attempt each part of the design brief.

Before students start on their prototypes, it's worth emphasising a few key points:
1. Focus on one element of the overall design. They don't need to build a prototype that meets all criteria, just one of the three listed in the design brief.
2. Use components from the practical activities they've done previously in the unit to support their work.
3. Their model doesn't need to be perfect at the end of the lesson. The goal is to describe how this could work, using evidence they gather throughout the engineering challenge.

Note that all of the examples we provide use the electromagnetic train as a starting point. We've found that this is a useful model to begin with, and then modify, based upon which criteria students want to meet.

Method

1. Coil the insulated wire around the PVC pipe or similar object. Leave about 2 cm out at either end.
2. Remove the coil from the pipe. Wrap the end of the wire around the coils to hold them in place. Make sure the ends of the wire stick out straight and are directly opposite each other.
3. Use the sandpaper to remove all insulation from one end of the wire. On the other end, remove only the top half of the insulation.
4. Bend the paper clips into long hooks with loops at the end.
5. Secure the battery to the table using Blu Tack.
6. Attach the paper clips to the battery terminals with electrical tape.
7. Place the neodymium magnet on top of the battery.
8. Insert each end of the wire coil into the paper clip loops. Make sure the exposed metal ends are touching the loops. If the coil doesn't start spinning, give it a gentle nudge with your finger.



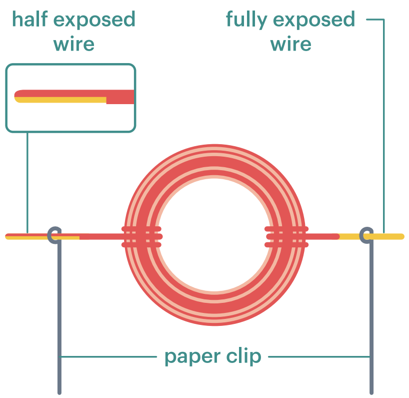
Final outcome

What you can expect to see at the end
The electric motors students produce at the end of this activity will likely vary due to a number of factors. The rate at which the electric motor spins will vary depending upon:
- the number of coils
- the distance between the copper coils and the magnet
- the strength of the magnetic field
- the current produced by the battery

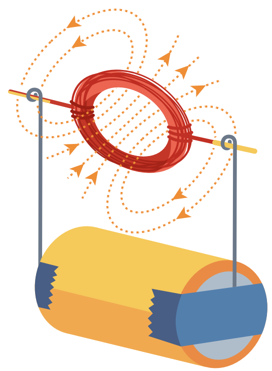
The direction that the electric motor spins will depend upon the orientation of the magnet relative to the direction current flows through the coils.

The electric motor functions based upon three simple steps:

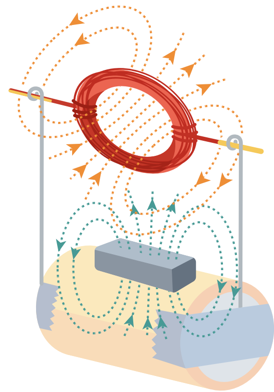
1. When the exposed part of the wire touches the paper clip, it creates a circuit. This allows an electric current to flow.



2. The electric current creates a magnetic field around the coil.



3. The magnetic field from the coil interacts with the field from the magnet. This causes the coil to turn.



In order for the coil to continue to spin, the circuit containing the copper coil must be broken. This prevents the magnetic field from the copper coil from permanently aligning with the magnetic field from the magnet. When the circuit is broken, momentum will allow the coil to complete its rotation, at which point the circuit reforms.

Appendix

Unit specific materials

Even if you don't buy the ***Non-contact forces and electricity: Essentials kit***, we recommend using the same materials. The following pages outline the specific materials that are in the kit, as well as how to prepare the materials for the classroom.

1 Magnets

In our development of the unit, we tested a wide range of magnets to see which produced the best outcomes. We strongly recommend using these same magnets, if possible, when you are teaching this unit

Equipment	Class set	Per group	Lesson
Neodymium magnet (rectangular)	16	2	**Magnetic accelerators**
Neodymium magnet (round)	16	2	**Magnetic slime** **Electromagnetic train**
Neodymium magnet (square)	16	2	**Magnetic accelerators**

Note: The type of bar magnets used in Lesson 6 doesn't impact on the outcomes of the activity as much as the neodymium magnets used in Lessons 3, 5 and 7. Any bar magnets are appropriate for the activity in Lesson 6.

2 Coiled copper wire

This unit requires coiled copper wire. Sourcing pre-coiled copper wire can be challenging. If you don't buy the Essentials kit, we recommend buying straight lengths of copper wire and coiling it yourself. This can be done without using any tools. It just requires a pre-cut piece of round wooden dowel. This round wooden dowel can then be used to store the copper wire until it's needed in the classroom.

We recommend either 22 SWG or 20 SWG copper wire. Wire thinner than 22 SWG is not recommended as it doesn't hold its form during experimentation.

Equipment	Length (per piece)	Class set	Per group	Lesson
Copper wire (20 SWG)	4.25 m (minimum)	8	1	**Electromagnetic train**
Copper wire (22 SWG)	4.25 m (minimum)	8	1	**Electromagnetic train**

Appendix

Preparing materials for the unit

① PVC pipe

The no-hands "tug-o-war" in **4. Electrostatic forces** requires sections of PVC pipe cut to length. Note that the size of the PVC pipe used isn't important. Feel free to adjust the diameter and length based upon what you have available.

The PVC pipe can be easily sourced from a local hardware store. It can then be cut to length with a hacksaw.

Equipment	Length (per piece)	Class set	Per group	Lesson
PVC pipe (20 mm)	30 cm	16	2	**Electrostatic forces**

② Wooden dowel

A number of activities require sections of wooden dowel cut to length. These materials are easy to source from a local hardware store. They can then be cut to length with a saw.

Equipment	Length (per piece)	Class set	Per group	Lesson
Square wooden dowel (12 mm)	30 cm	16	2	**Magnetic accelerators**
Round wooden dowel (12.5 mm)	30 cm	8	1	**Electromagnetic train**

Note: The size of the wooden dowel listed above is designed to match the size of the magnets recommended in this unit. If alternative magnets are used, the size of the dowel may also need to be adjusted.

Appendix

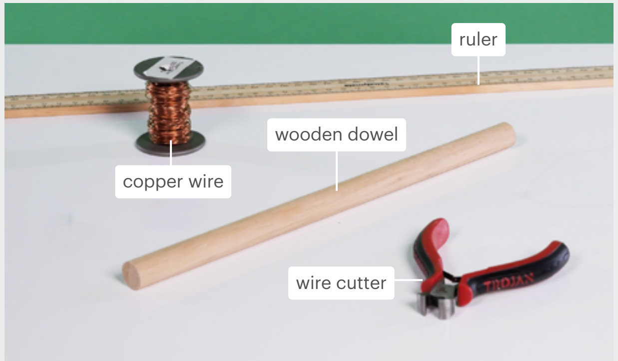
Coiling copper wire

Watch the demo video

stileapp.com/go/ncfcoilingcoppervideo

Materials

Each group of students will need:
- copper wire
- wire cutter
- 12.5 mm round wooden dowel
- ruler

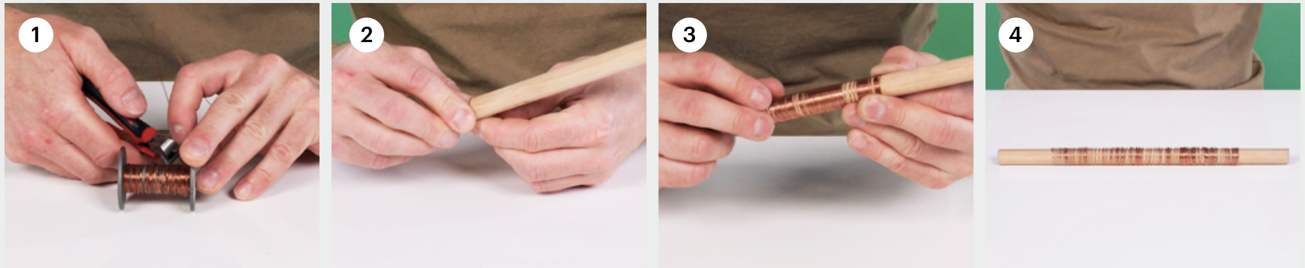


Preparation

Before coiling the copper wire, you'll first need to cut 30 cm lengths of round wooden dowel. You will need one 30 cm length of wooden dowel for each copper coil you make.

Method

1. Cut a 4.25 m length of copper wire.
2. Firmly hold one end of the copper wire against the round wooden dowel.
3. While pressing down firmly, slowly rotate the wooden dowel to coil the copper wire.
4. Once complete, store the coiled wire on the wooden dowel.



Call us on 1300 918 292

Email us at community@stileeducation.com

Swing by the office to say hi!
Level 5, 128 Exhibition Street, Melbourne, Victoria

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