COSMOS LESSONS

Physics

Energy Transformations: Powering tomorrow's vehicles

In this lesson you will look at energy transformations, and in particular, a new design feature on the electric car.

- You will explore the following:
- What is the Law of Conservation of Energy?
- How can you identify energy transformations?
- How does a lithium ion battery work?

So get ready for a fast and furious ride!

Introduction: Energy (P1)

When cars were first invented, electricity was the first choice for powering them. Electric cars held the land speed record until 1900 and could travel at more than 100 kph. But within 15 years there were hardly any electric cars on the road, and nearly every car had a petrol engine. So what happened?

The problem was that people worried about getting stuck with a flat battery. And in those days it was harder to find sources of electricity than it is today.

Until now, battery technology has held us back from the efficiency and low emission benefits of electric vehicles. The range of a fully charged electric car is much less than a petrol car with a full tank. But a recent innovation may change all that.

The German carmaker BMW has come up with an electric car with a battery that should never go flat.

In the new BMW i3, an electric motor always drives the wheels. So what happens when the battery gets low? A small petrol engine begins to work – not to drive the wheels but to run an electric generator that charges the battery. Problem solved!

Read or listen to the full *Cosmos* magazine article here.

Petrol stations, with pumps like the ones on the left, are everywhere, but for electric car drivers it is a long way between recharging stations like the one on the right. Credit: iStock

Question 1

List: Using a pro-con table, list the benefits (pros) and disadvantages (cons) that the average motorist may have when owning, driving and travelling in an electric car.

Hint: If you have not used a pro - con table before, the idea is to brainstorm the pros and cons that immediately come to mind, then for every pro or con that you have written, write its analogous (matching) opposite next to it. So each line in the pro - con table should have an advantage and disadvantage about the same idea.

Pro	Con

Gather: Energy (P1)

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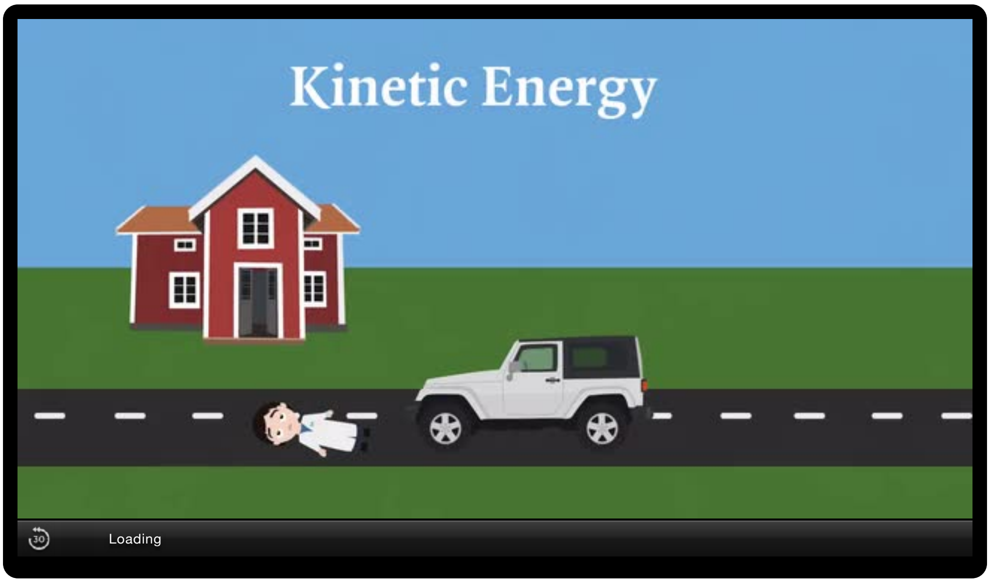


Credit: Studi School / YouTube.

Question 1

The Law of Conservation of Energy states that energy cannot be created or destroyed.

- ○ True
- ○ False

Question 2

Energy of one type can never be transformed into energy of a different type.

- ○ True
- ○ False

Question 3

Kinetic energy can also be described as

- [ ] potential energy
- [ ] movement energy
- [ ] electrical energy
- [ ] nuclear energy

Question 4

When electricity from a charging station is used to charge the battery of an electric car and then the car is driven away, this is an example of

- [ ] thermal energy converted to chemical potential energy converted to kinetic energy
- [ ] electrical energy converted to nuclear energy converted to chemical energy
- [ ] electrical energy converted to chemical potential energy converted to kinetic energy
- [ ] electrical energy converted to thermal energy converted to kinetic energy

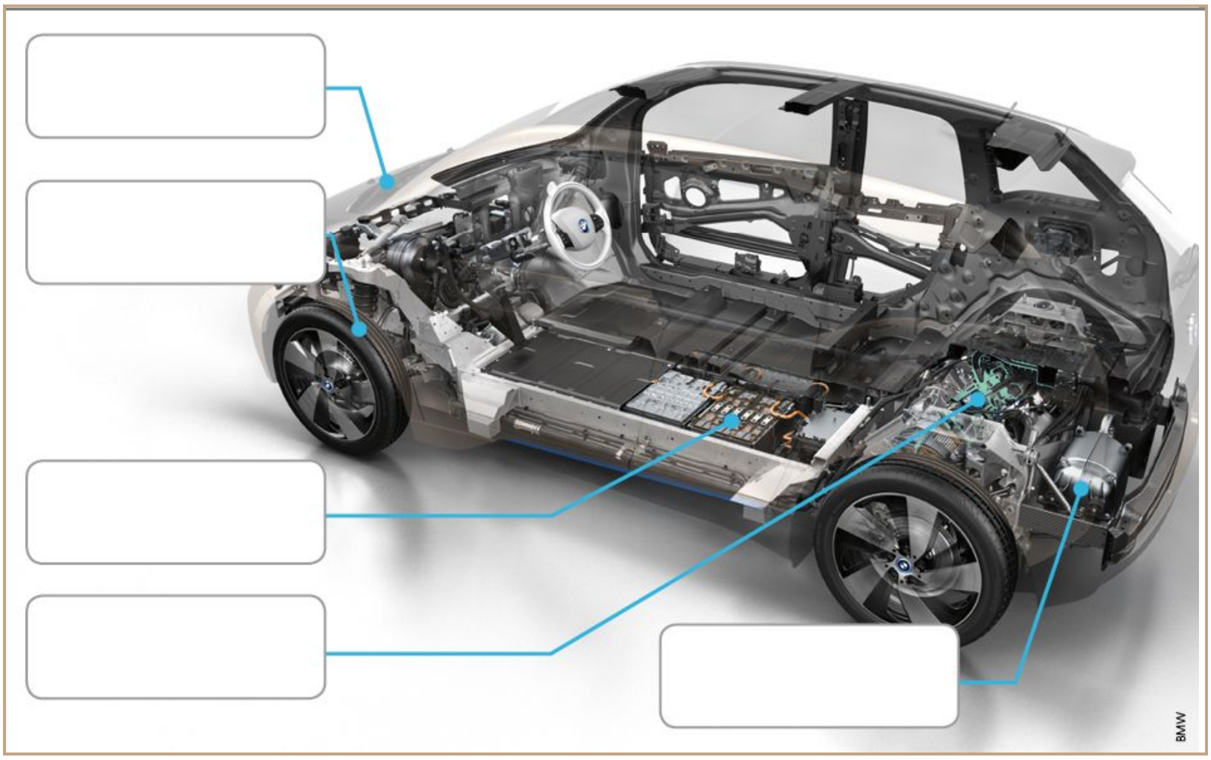
Question 5

Identify: In the table below, name the types of energy described in the video and beside each energy type list two examples where you may see that type of energy.

Type of energy	Example 1	Example 2

Question 6

Match: The *Cosmos* article lists five efficiency features of the BMW i3 range-extender car. On the diagram below, use the text tool to label the features and briefly summarise their efficiency feature.



Question 7

Distinguish: The *Cosmos* article describes a feature that will help buyers deal with their range anxiety. What is this feature and how does it work?

Process: Energy (P1)

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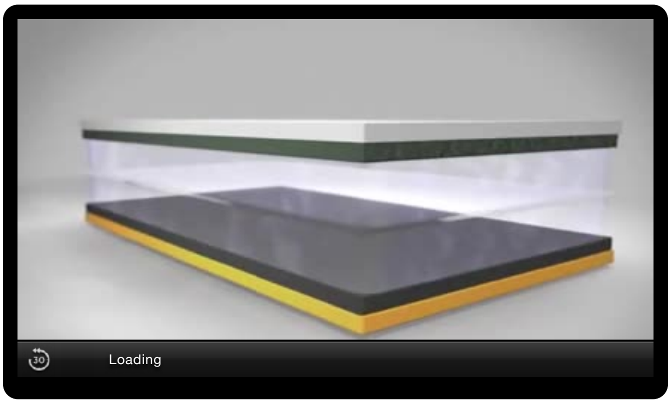
With a petrol engine you have to regularly refuel at a petrol station but electric cars like the BMW i3, right, can be recharged overnight at home. Their small petrol engine is only used to generate electricity to charge the battery if it gets low.



Credit: BASF / YouTube.

Question 1

Recall: When a battery is charging, positive lithium ions move from the cathode through the separator to the anode for storage.

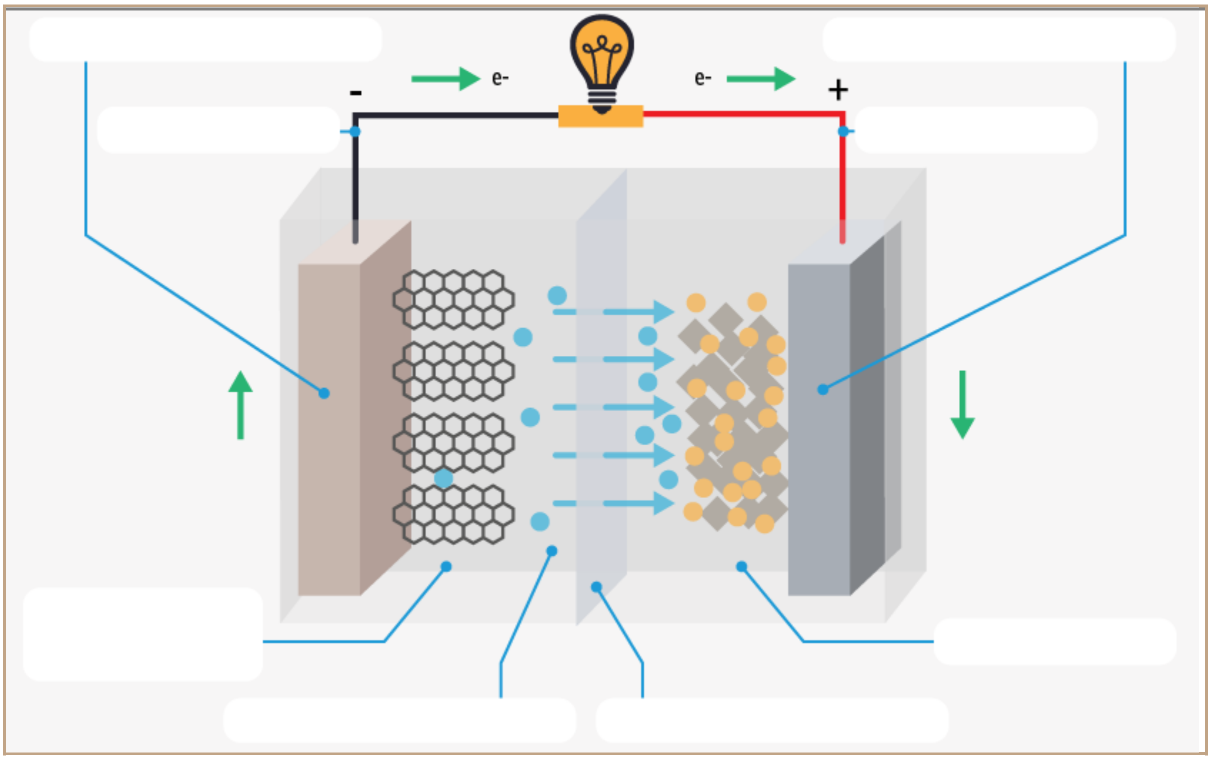
- True
- False

Question 2

Distinguish: The following terms were used in the video about how electric car batteries work:

anode, cathode, aluminium conductive surface, copper conductive surface, pure lithium metal oxide, a form of carbon with a layered structure, transport medium, separator

In the sketchpad below, use the text tool to label the diagram.



Question 3

Connect: The table below lists the elements of the lithium ion battery. In the column next to each part of the battery is a description of what that part of the battery does. They are not currently arranged correctly. Draw a line from the first column to the second to match the battery part and its function.

lithium metal cathode (+)	negative electrode, one of the conductive surfaces that transports electricity out of the cell
graphite anode (-)	prevents a short circuit, placed between the cathode and anode
electrolyte	transport medium to allow Li ions to flow freely
separator	transports current to the cell
conductive surfaces	positive electrode, one of the conductive surfaces that transports electricity or electric current into the cell

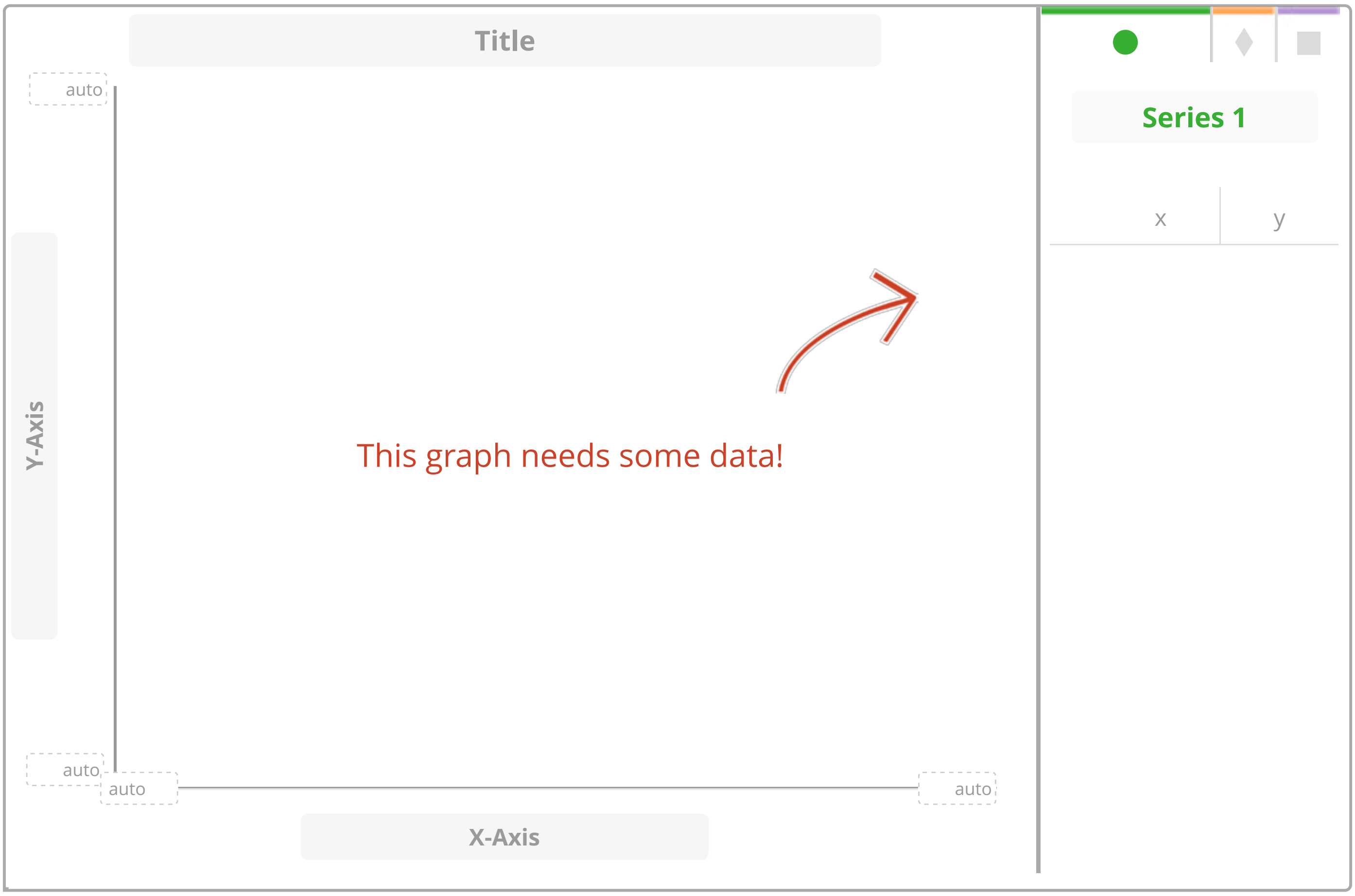
Question 4

Recall: Why is it important for the lithium metal oxide to be pure, to have a uniform chemical composition?

Question 5

Graph: The *Cosmos* article states that the BMW i3 can go from 0 to 100 kilometres per hour (kph) in just 7 seconds. Plot this information in the graph below by putting velocity in kph on the vertical axis and time in seconds on the horizontal axis. You should assume that there is a linear relationship between velocity and time, in other words, that the graph will be a straight line.

Hint: Remember to adopt good graphing techniques by labelling each axis, including units.

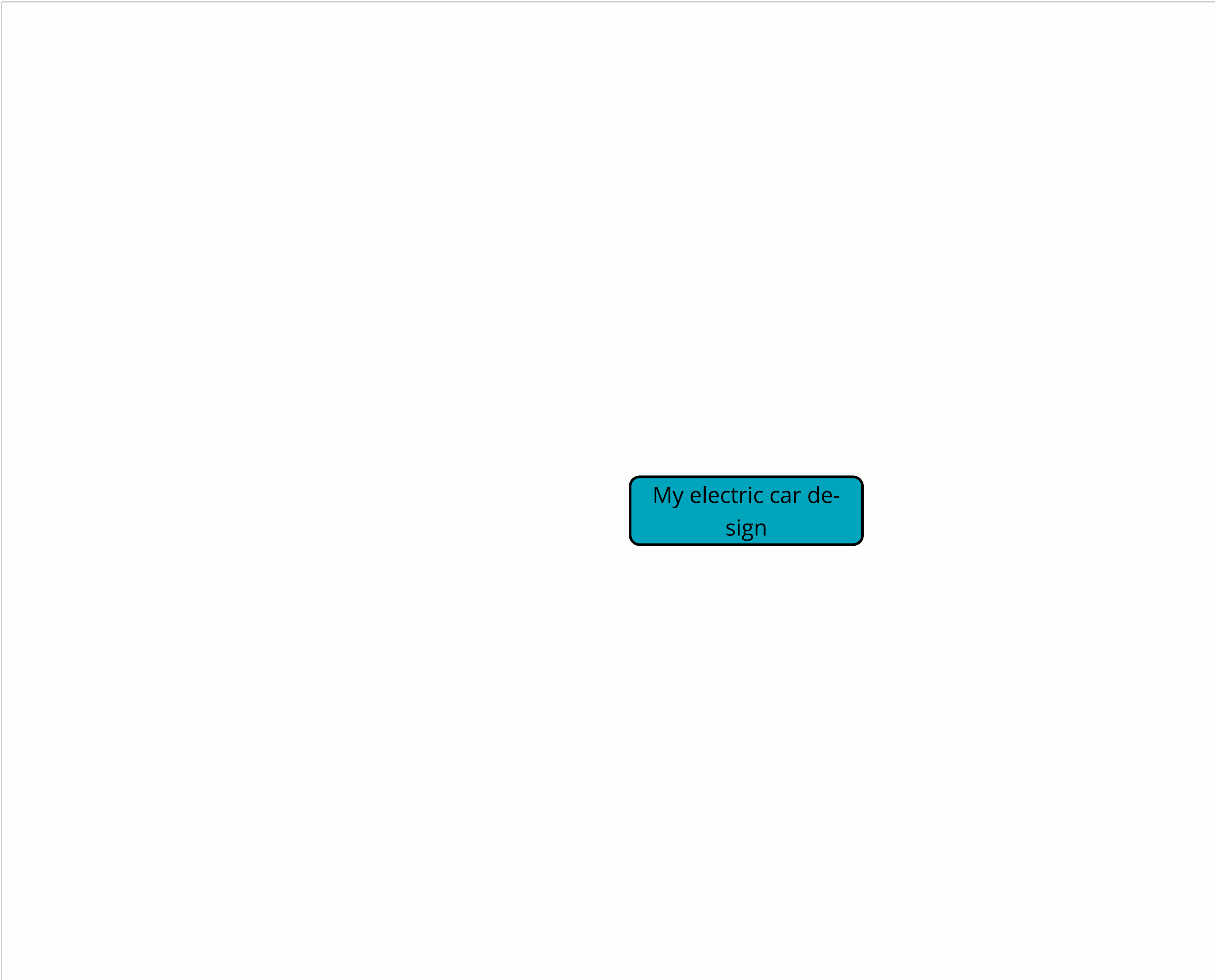


Question 6

Interpret: Using your graph in the previous question, estimate how long would it take for the car to reach a speed of 60 kph from a stationary start.

Question 7

Design: You have been asked to design an electric car. The brief is to make it as energy efficient and functional as possible and the intended market is 20 - 25-year-old buyers. Use the mind mapping tool below to identify all the features you would want to include in this design.



Apply: Energy (P2)

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Experiment design: Demonstrating energy transformations

A toy windmill, a wind up car, a battery powered torch, a radio, a catapult, a Hot Wheels car track with a loop the loop section and an electric light globe all show ways energy is transformed. Credits: iStock and Leonard Gertz/Corbis

In this task you are to work with a partner to design an experiment suitable for Grade 5 primary school students. The experiment is to investigate energy transformations in toys and devices. Make sure that your experiment contains the following sections as well as model answers and mark allocations.

Aim

The aim of the experiment is to use various toys and devices to identify energy conversions.

Materials

- A toy windmill
- A wind up car
- A battery powered torch
- A radio
- A catapult
- A hot wheels car track with a loop the loop section
- An electric light globe

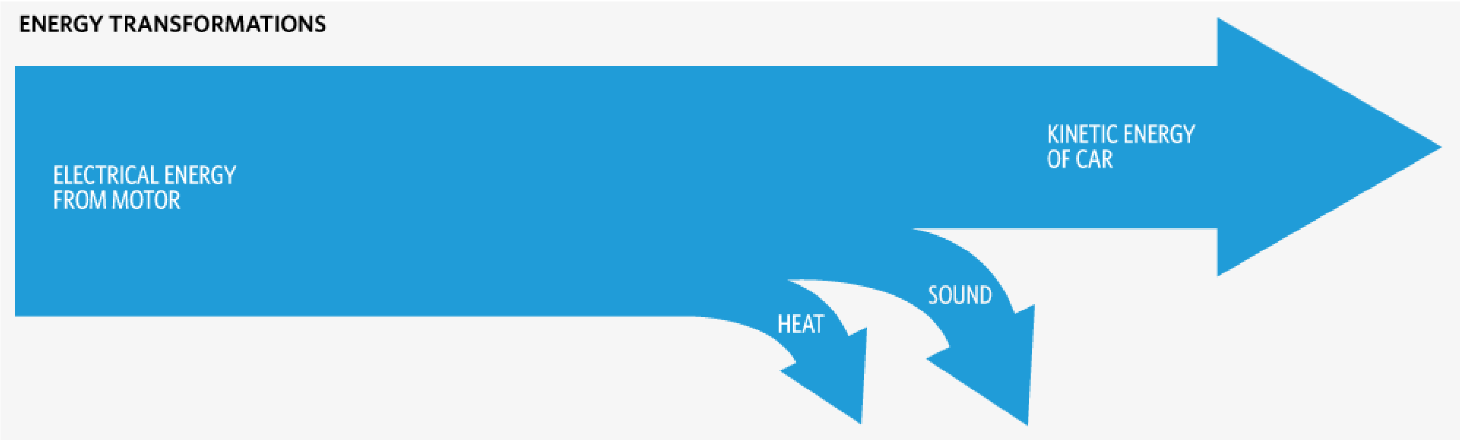
Procedure

This is the part where you are the authors. How are you going to set up each of these demonstrations and what are you going to ask the Grade 5 students to do? Are you going to set it up as a "round robin", where there are different stations and groups of students move from activity to activity? Or are you going to going to provide sufficient equipment so the students can carry out all the experiments in their group? How many students will you place in each group?

Results

Design the results table that the students will need to fill in for each of the activities. The table should allow the Grade 5 students to state the types of energy they observe in each situation. In addition, for each situation they are to draw a Sankey diagram to represent the energy changes that are happening.

As an example, the motor in the electric car in the *Cosmos* article converts electrical energy into kinetic energy, a little bit of heat and a little bit of sound energy. A Sankey diagram that represents this energy conversion could be drawn like this:



Discussion

You should write this section as a series of questions. The questions should be designed to help the Grade 5 students interpret their results.

Conclusion

In this section, write what you think may be an expected conclusion for the experiment. A conclusion should address the aim and briefly summarise the results and discussion.

Question 1

Design: Create your experiment design in the project space below.

Career: Energy (P2)

Brought to you by the University of Adelaide

Imagine a fast, sleek Formula 1 race car that doesn't need fuel, or an aircraft with a giant propeller and parachute that runs on battery power. Electric vehicles can take many different forms, and Dr Clint Steele's job is to design them so that they are efficient, stylish and safe.

Dr Clint Steele's job is to design electric vehicles so that they are efficient, stylish and safe. Credit: Paul Jones

Clint's interest in vehicle design was sparked while reading a *Hot Rod* magazine, which had tips on how to improve a car's performance by modifying its internal mechanics. He found himself completely engrossed and was left with a thirst to discover how things work and how to make them work better.

After working as a design engineer in China and Australia, Clint is now a senior lecturer at Swinburne University's School of Engineering. He still has the same drive to make things work better, and uses it to improve the design and performance of electric vehicles. Designing electric vehicles is challenging – they need to be strong and sturdy, yet aerodynamic and light. It's an exciting, pioneering field and Clint says that he is constantly learning new things through experimentation and research.

As a lecturer and researcher, there is rarely a chance to be bored. In a day's work Clint will meet with industry representatives, plan course work, help students with projects, present lectures, and mark student work. One day he might be designing a propeller or transmission system, and the next, researching a new material or how to improve a vehicle's aerodynamics.

It may come as a surprise to some that when he's not working, Clint loves ballroom dancing. He says, "Few would pick it when they look at me, but I can recommend it to anyone. Once you try it, you will know why!"

Question 1

Research: Access the Swinburne University Engineering undergraduate degrees website. Choose an area of engineering that sparks your interest and read the overviews and career opportunities listed for each course.

What was your chosen area of engineering? Write a summary of the career opportunities for this branch of engineering.

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