Southern Cross University

The SCU Electric Kombi Conversion Project

iSTEM Module 6
The Electric Kombi Conversion

Southern Cross University

Introduction

Dear Educators,
Adopting a student-focused, inquiry-based model, the Southern Cross University Electric Kombi Conversion Curriculum Package is a unique unit program which includes a detailed unit map of 30 lesson plans that align with the iSTEM program outcomes and objectives including the iSTEM 8 cog process for STEM inquiry.

The package also includes a suite of purpose developed videos to accompany the program featuring speakers from industry and the university including Southern Cross University Vice President (Engagement), Ben Roche; Project Leader, Industry Engineer and Southern Cross University Alumnus, Andy Naughton; Industry Leader in Renewable Energy, Nick Lake; Current Southern Cross University Engineering Student, Max Den Exter; and, Academics from the Faculty of Science and Engineering including Dr Ricardo Vasquez Padilla and Dr Maree Lake. The package also provides links to relevant educational resources including YouTube clips, interactive web applications, templates, background teacher information and more.

This curriculum package is designed by STEM experts with student engagement and experience at the fore to ensure it enables students to develop the 21st century skills necessary for their future careers.

We trust you and your students will enjoy and we look forward to working with you.

Warm regards,
Simone Blom and Dave Ellis,
Southern Cross University, Faculty of Education.

This curriculum-linked resource was produced by Southern Cross University. It is designed for educators to utilise as an introduction for students to the principles of STEM using the example of an Electric Kombi conversion project undertaken by engineering experts at the University.

All links to websites were valid as of July 2021. As content on the websites used in this resource book might be updated or moved, hyperlinks may cease to function.

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Contributors

Simone Blom

BSc, BTeaching, BEd (hons), PhD Candidate

Simone began her career in education two decades ago. With academic qualifications in science and primary and secondary teaching, she has held a variety of teaching roles during this time, including delivering programs to students from kinder, primary, secondary and tertiary levels. Simone has been employed as a teacher and environmental education consultant in numerous states and territories in Australia. Simone has also had experience as a Head of Science, a school Sustainability Officer and a VCAA assessor. She has worked in collaboration with community groups, and other schools and government departments to create strong, award-winning science-based programs that focus on the environment and increase students' engagement and awareness in science and environmental issues. Since settling in NSW, Simone has been working in the tertiary sector delivering science and technology education workshops to pre-service teachers and working with in-service teachers through professional development workshops in Australia and Indonesia for nearly ten years.

Dave Ellis

B.Ed (Secondary Industrial Arts), MUDS, PhD Candidate

Dave Ellis is a former high school technology teacher, head teacher and VET coordinator who has worked across both New South Wales State and Catholic Education systems. Following a successful high school teaching career, Dave decided to undertake some postgraduate study out of an interest in sustainability and completed a Masters in Urban Development & Sustainability (MUDS). Dave started lecturing in the Bachelor of Technology/ Bachelor of Education program at Southern Cross University where his research interests reside in teacher expertise and professional learning. This formed the basis of his PhD research. Dave is currently the Acting Chair of Discipline in Postgraduate Teacher Education. In recent years, Dave has been the Deputy Course Coordinator for the Bachelor of Technology/Bachelor of Education program at Southern Cross University, and has been involved in the development of Teacher Subject Content Knowledge policy with the NSW Educational Standards Authority (NESA) and the accreditation of Initial Teacher Education programs with the Australian Institute for Teaching and School Leadership (AITSL). Dave has published in books and journals a number of areas, such as interdisciplinary (STEM) projects, project-based learning, communities of practice and Stage 6 student texts. All of these publications stem from a desire to assist teachers in the development and maintenance of their expertise.

Summary

Duration: 10 weeks - 25 Indicative hours

Students will be required to complete a Kombi Upgrade Design and Evaluation Report which documents their process in developing a model of an electric vehicle that can travel for at least 20 metres unaided.

Topic 1:

The case for re-thinking car fuel sources (energy)

Topic 2:

Understanding car engines – the basics (electronics)

Topic 3:

Understanding car engines – utilising renewable and non-renewable energy sources (energy) including comparing electric and petrol/diesel engines

Topic 4:

Understanding car engines – gyroscopes, accelerometers, sensors (technologies related to motion)

Topic 5:

Introduction to CAD design – developing a prototype (electronics)

Topic 6:

Electric car engine design (developing projects related to motion)

Topic 7:

Electric car engine conversion/ manufacture (developing projects related to motion)

Topic 8:

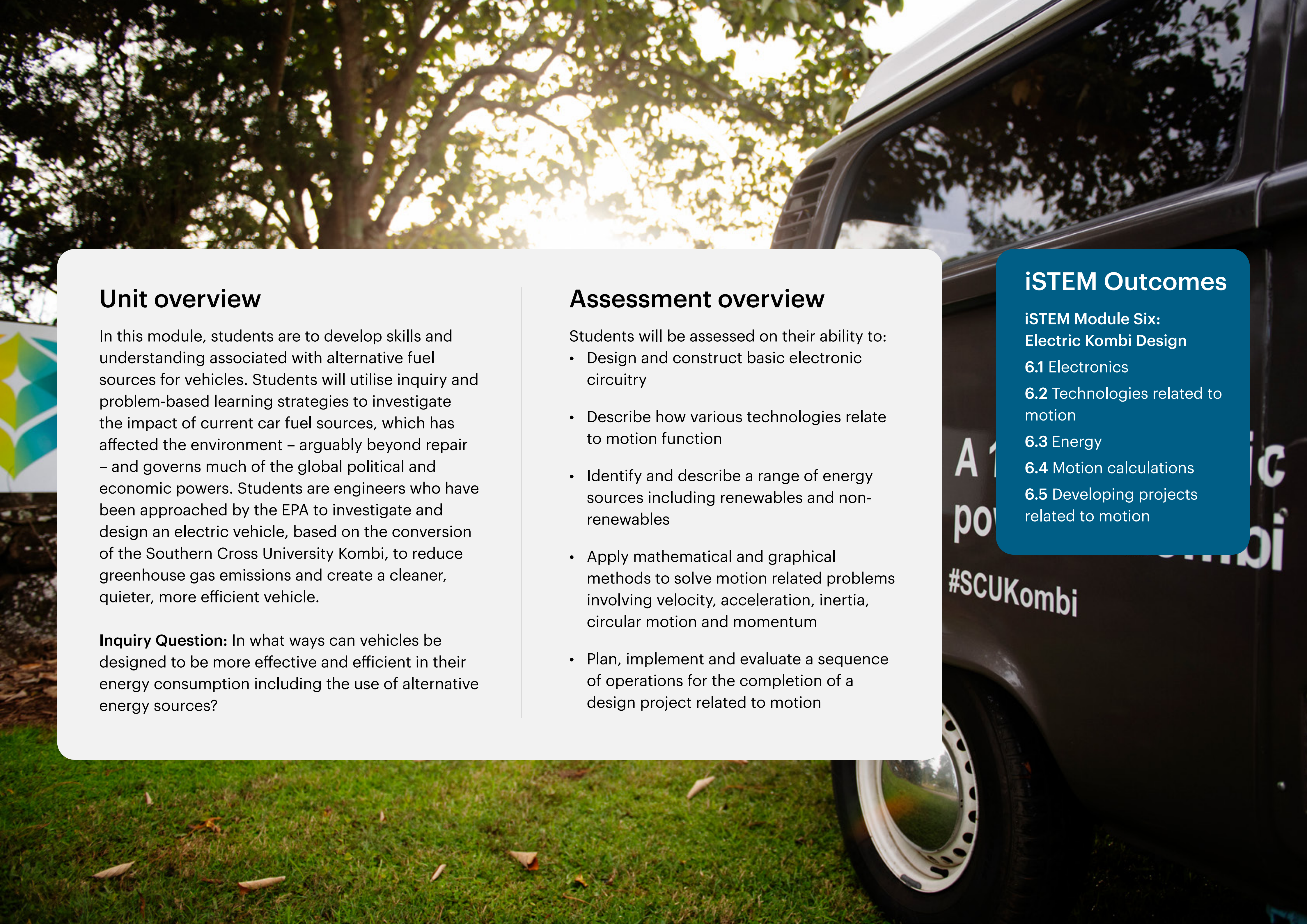
Evaluation Report – testing and evaluating (motion calculations)

Topic 9:

Cardboard Kombi Testing and Evaluation

Topic 10:

Cardboard Kombi Testing and Evaluation part 2



Unit overview

In this module, students are to develop skills and understanding associated with alternative fuel sources for vehicles. Students will utilise inquiry and problem-based learning strategies to investigate the impact of current car fuel sources, which has affected the environment – arguably beyond repair – and governs much of the global political and economic powers. Students are engineers who have been approached by the EPA to investigate and design an electric vehicle, based on the conversion of the Southern Cross University Kombi, to reduce greenhouse gas emissions and create a cleaner, quieter, more efficient vehicle.

Inquiry Question: In what ways can vehicles be designed to be more effective and efficient in their energy consumption including the use of alternative energy sources?

Assessment overview

Students will be assessed on their ability to:

- Design and construct basic electronic circuitry
- Describe how various technologies relate to motion function
- Identify and describe a range of energy sources including renewables and non-renewables
- Apply mathematical and graphical methods to solve motion related problems involving velocity, acceleration, inertia, circular motion and momentum
- Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion

iSTEM Outcomes

iSTEM Module Six: Electric Kombi Design

6.1 Electronics

6.2 Technologies related to motion

6.3 Energy

6.4 Motion calculations

6.5 Developing projects related to motion

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STEM Process
1. DEFINE

Topic 1 The case for re-thinking car fuel sources

Inquiry Question 1: Why are conventional fossil-fuel reliant vehicles a problem for human and environmental health?

6.3 Energy
Students learn about:
- energy sources

Students learn to:
- identify and describe a range of energy sources including renewables and non-renewables

[Introduction and background to the unit:
See Video 1.1.1: Electric Kombi Project Introduction]()

Lesson 1:

- **Card sort:** Why do we need oil? Ask students what products they use that contain oil. Give student groups a deck of picture cards (print and laminate images so they can be reused) – some which are products made from oil (e.g. plastics give examples like basketball, sunglasses, plastic bag, telephone, some candle wax, some lip balms, shampoo and other cosmetics, some fertilisers, some clothing, some pillows etc.) and non-plastics (clothing made from natural fibres, cosmetics made from alternative products, products made from wood, metal etc.
- **Whole class discussion:** Where does oil come from? Brainstorm on the whiteboard.
- **Video 1.1.2:** Video bingo – have 3 x sheets of different questions and students have to answer the questions on their sheet (that the answers are given for) and first to complete says bingo. In groups of 3, students go through their responses by swapping sheets and discussing each answer.
- **Video 1.1.3: Whole class discussion:**
- **pre-video:** How is oil turned into fuel?
- **post-video:** Do you think the different types of fuels have different functions and impacts on the environment? Do you think this video was made by a crude oil producer? Do you think there are any waste products?
- **Video 1.1.4:** The impact of car emissions on local atmospheric CO2. Students can take notes to address the 'take home questions' (see below).
- **Article for summary:**
Read the whole article aloud, choose a student to or ask students to read some of all of it for homework. Students can take notes to address the 'take home questions' (see below).
- **Take home question:**
What would happen to current CO2 atmospheric levels if there were no car emissions? What are some other impacts of diesel or petrol powered cars on the environment?

Topic 1

The case for re-thinking car fuel sources

Inquiry Question 1: Why are conventional fossil-fuel reliant vehicles a problem for human and environmental health?

STEM Process
1. DEFINE

Lesson 1 Resources

- Video 1.1.1: Electric Kombi Project Introduction
  Introduction and background information about the Kombi Conversion Project with Ben Roche
- Card sort: Products made from oil
  Use this list to get some associated images together and laminate them into cards so they can be reused.
- Video 1.1.2: Oil 101
  (2 min 16 sec) by www.studentenergy.org
- Video 1.1.2: Oil 101 Video bingo Questions:
  - What else is oil known us?
  - What is oil composed of? List at least 3.
  - What are some properties of oil?
  - How was oil formed?
  - How long does oil take to produce?
  - Where is oil found?
  - Who locates oil deposits?
  - What technologies are used to find oil?
  - Where is oil processed?
  - List 3 products that come from oil from this video?
  - What are the major uses of plastics by humans?
  - What are some of the environmental issues of using and producing oil?
  - What are some of the social issues of using and producing oil?
- Video 1.1.3: Petroleum refining processes explained simply
  (2 min 48 sec)
- Video 1.1.4: What did COVID-19 do to the Bay Area's air quality?
  (STOP @ 3 mins)
- Article for summary

Topic 1 The case for re-thinking car fuel sources

Inquiry Question 1: Why are conventional fossil-fuel reliant vehicles a problem for human and environmental health?

Lesson 2:

- **Teacher demonstration:** Students come to the front of the classroom and watch a teacher demo: lighting a tealight candle or with the yellow flame of the Bunsen burner the teacher collects the carbon on a white tile. Questions to students: What is this black substance? Where has it come from? What happens to this substance if not collected on the tile? Discuss carbon dioxide and the common sources in our daily lives. Link to homework – the impact of cars/motor vehicles. The technology of petrol/ diesel powered engines is old but is still utilised in most vehicles.
- **Video 1.2.1:** Students construct a diagram to map the energy transformations that an engine undertakes. Discuss efficiency.
- **Activity 1.2.1:** Students to read the 4 page factsheet on transport emissions from the Climate Council of Australia and make an infographic that states 3 key points from the factsheet. Present using CANVA or alternative web-based application.
- **Present:** Students present their findings : What is the biggest issue with the design of current combustion cars?
- **Defining and identifying the problem:** what can we do to address climate change and reduce CO2 production? Teacher to brainstorm ideas on the whiteboard. Use the example of the conversion of the SCU Kombi – what are some of the benefits and limitations of using an existing vehicle and changing its energy source?

Lesson 2 Resources

- Video 1.2.1
  The technology of a diesel engine that demonstrates the many stages of energy transformations that have to be gone through to make the engine work
- Activity 1.2.1
  Climate Council of Australia Fact Sheet

STEM Process
2. IDENTIFY

Topic 1

The case for re-thinking car fuel sources

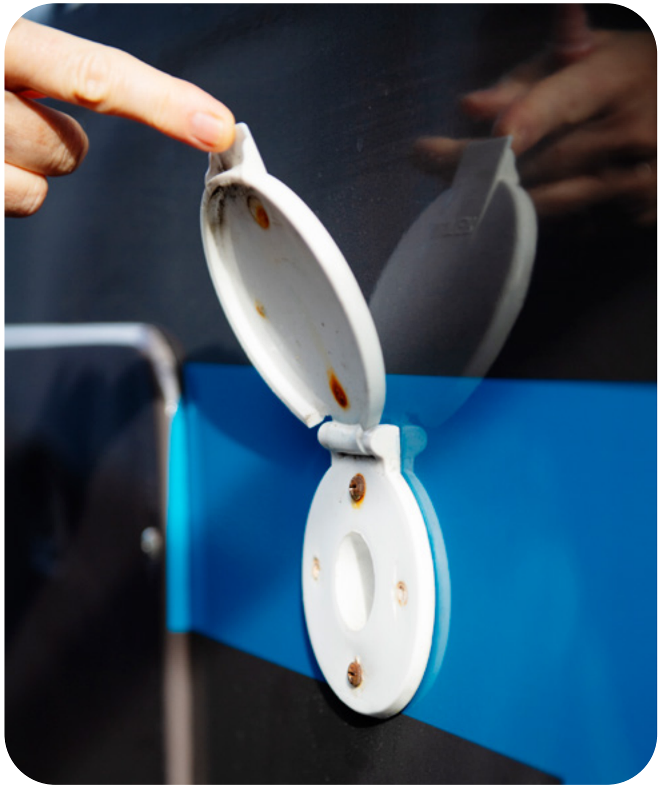
Inquiry Question 1: Why are conventional fossil-fuel reliant vehicles a problem for human and environmental health?

Lesson 3:

- **Activity 1.3.1:** Simple machines – see resources for link to lesson plan which includes a PowerPoint, worksheet and scavenger hunt for students to engage with.
- **Whole class discussion:** What are the benefits of simple machines? Ask students to provide some explanations about how the simple machines work. Have a discussion about Mechanical Advantage.
- **Student activity 1.3.2:** Work with students to build a simple machine using a product such as Knex (see resources).

Lesson 3 Resources

- Activity 1.3.1
  Engineering: Simple Machines
- Whole class discussion
  Teacher background information about Mechanical Advantage
- Activity 1.3.2
  Knex education Simple Machines Levers and Pulleys set
  Knex education Simple Machines Gears set



Topic 2

Utilising renewable and non-renewable energy sources (energy) including comparing electric and petrol/diesel engines

Inquiry Question 2: How does a vehicle's chosen energy source contribute to the effectiveness, efficiency and overall sustainability of powering the vehicle?

6.1 Electronics
Students learn about:

- circuitry
- motors & generators
- fault detection
- prototypes
- making models
- practical application

Students learn to:

- Design and construct basic electronic circuitry Develop basic motors and generators
- Use fault diagnosis techniques to isolate problems Use multimeters to test circuits and components Use continuity testers/multimeters in the production and testing of practical projects
- Develop prototypes using a variety of materials to simulate motion produce models in order to solve problems related to motion

Lesson 4:

- **Facilitation technique Stay-and-stray:** Are electric vehicles better than petrol ones for the environment - why? Argue and justify your point of view!
- **Video 2.4.1 & 2.4.2:** Comparison of electric and diesel vehicles.
- **Whole class discussion post-video questions:** What are they measuring in this video to make their assessment? What other factors aside from the environment are important to consider in deciding whether to use petrol/diesel or electric vehicles?
- **Video 2.4.3 & 2.4.4:** Students are to identify 3 differences between the operation of a diesel engine and an electric engine.
- **Whole class discussion:** How do you conduct an evaluation? How does an evaluation include the ideas of the pros and cons/trade-offs? Teacher records the process for evaluation on the whiteboard.
- **Investigation:** Students plan an investigation which explores the difference between a number of vehicles powered through different sources. The investigation planning includes formulating a set of criteria to evaluate the effectiveness and efficiency of different types of vehicles that use renewable and electric energy (see the NSW Syllabus Working Scientifically process and the Working Technologically link in the resources section).

Topic 2

Utilising renewable and non-renewable energy sources (energy) including comparing electric and petrol/diesel engines

Inquiry Question 2: How does a vehicle's chosen energy source contribute to the effectiveness, efficiency and overall sustainability of powering the vehicle?

Lesson 4 Resources

- **Stay-and-stray:** Students are arranged in groups of 3 in a circle around the room (if numbers don't permit, students form pairs). Each student chooses either A, B or C (pairs just choose A or B). In their group students discuss the question. Then, student A moves anti-clockwise to the next group, student B stays or 'be' where they are and student C moves clockwise to the next group. Student do this once more and then each group reports back on the key points from their discussion.
- Video 2.4.1: Electric Cars & Global Warming Emissions
  Electric Kombi Project Video 2.4.2: Environmental Impacts Of Diesel And Electric Engines
- Video 2.4.3: How It Works: Internal Combustion Engine
  Electric Kombi Project Video 2.4.4 what is the difference between a diesel and electric engine?

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STEM Process
3. BRAINSTORM

Topic 2

Utilising renewable and non-renewable energy sources (energy) including comparing electric and petrol/diesel engines

Inquiry Question 2: How does a vehicle's chosen energy source contribute to the effectiveness, efficiency and overall sustainability of powering the vehicle?

Lessons 5 & 6:

- **Investigation:** Students conduct the investigation using the vehicles they have access to e.g.:
  - Solar Wind
  - Solar PV (inc. battery)
  - Biomass (as biofuels)
  - Hydrogen
  - Electric
- **Videos:** The teacher may show videos prior to the investigation for ideas and inspiration or afterwards to demonstrate alternative ways of approaching the task.
- **Report:** Students are to write up an evaluation report of their findings for submission (assessment 1).

Lessons 5 & 6 Resources

- **Investigation (Lesson 5):**
  Working scientifically
  Working technologically
  (see p. 29 – 31 of download
- **Investigation (lesson 6):**
  - Wind powered car
    Video 1
    Video 2
    Wind pros/cons
  - Solar PV
    Video 1
    Solar pros/cons
    STELR Solar car resource
  - Biomass as biofuels
    Video 1
    Biofules pros/cons
  - Hydrogen cars
    Salt water engine car kit
    Salt water fuel cell car kit
  - Electric car
    Video 1
  - Other possible renewable alternatives
    The elastic car
    The magnetic car
- **Assessment 1:** Evaluation report of the investigation and design process.

STEM Process
3. BRAINSTORM

Topic 3

Applying the learning – a design challenge using renewable energy

Inquiry Question 3: What design approach is more efficient at moving a model Kombi 20 metres?

6.3 Energy:
Students learn about:
- **energy sources**
- **motors**
- **electric vehicles**
- **motion**

Students learn to:
- Identify and describe a range of energy sources including renewables and non-renewables
- Utilise electric motors to develop a project related to motion
- Select and use a range of components and hardware in the development and production of a practical project related to motion

Lesson 7:

- **Video 3.7.1: The Engineering And technology Design Process** Students consider how to approach STEM design challenge using the example of the Kombi Project.
- **Student Design Challenge:** Students are given the challenge that will span the remaining duration of the unit. This is the initial lesson where the teacher presents the information.
  - Design and create a cardboard Kombi vehicle powered from a renewable energy source and travel 20 metres distance.
  - Use the solar care challenge to assist and model this activity.
- **Report:** Students are to write up an evaluation report of their findings for submission (assessment 1).
- **Two design challenge categories.** Students to choose from either:
  - Using a method to transfer energy from the motor to the wheels (see video 3.7.2 and video 3.7.3), or
  - Using a method of producing forward motion using the movement of air (see video 3.7.4).
- **Whole class brainstorm:** Before the design work begins, students consider the design success criteria: What is the success criteria? What will be the measure of if the prototype is successful? Class decide on a collective set of design criteria to guide, development and evaluate the projects e.g., students are to work in pairs.
- **Video 3.7.5: Meet The Makers.** Students to consider the benefits of retrofitting an old car with new technology.

STEM Process
3. BRAINSTORM

Topic 3

Applying the learning – a design challenge using renewable energy

Inquiry Question 3: What design approach is more efficient at moving a model Kombi 20 metres?

Lesson 7 Resources

- Video 3.7.1: The Engineering And Technology Design Process Andy Naughton, the Engineer responsible for the Electric Kombi Conversion, discusses the design process that he utilised in converting the Kombi from diesel to electricity (stop @ 2:25min).
- **Design challenge:** Solar car challenge set the parameters for the challenge with the students. It is not only about speed!
- **Solar circuit charger:** such as garden lights – this would be used to drive the vehicle.
- Example of Cardboard Kombi template (see template and instructions in the attached appendices).
- Video 3.7.2. Energy transfer example 1: Energy transfer from a motor to a wheel using gears: measuring the RPM of a Lego wheel under different situations.
- Video 3.7.3. Energy transfer example 2: Energy transfer from a motor to a wheel using voltage and polarity. Teachers may need to explain what is happening here.
- Video 3.7.4. Energy transfer example 3: Energy transfer from potential electrical energy to kinetic energy: making 'toys from trash' using the movement of air.
- Video 3.7.5: Meet The Makers Andy Naughton, the Engineer responsible for the Electric Kombi Conversion, and Southern Cross Engineering Student, Max Den Exter discuss the influences on his career path and the Kombi project including the benefits of converting old cars with new technologies.

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STEM Process
3. BRAINSTORM

Topic 3

Applying the learning – a design challenge using renewable energy

Inquiry Question 3: What design approach is more efficient at moving a model Kombi 20 metres?

Lessons 8 & 9:

- **Learning intention:** Students are taught about electricity and how motion can be created using electronic components.
- **Teacher demonstration:** Electron Flow. Using a battery energy source and an LED or a buzzer, and a motor. Demonstrate how electron flow is evidenced in light, sound and or movement (see resources).
- **Key Questions:**
  - What impact does voltage have on electron flow?
  - What happens to the motor when the polarity is changed?
- **Video 3.8.1: The Batteries Used In An Electric Vehicle.** Students consider the role of the battery in an electric vehicle.
- **Video 3.8.2:** Students consider the issues and impacts of electric vehicles through their use of batteries.
- **Teacher demonstration:** how electrons can be 'controlled' using components. Teacher introduces resistors and variable resistors (potentiometer).
- Key Questions:
  - What happens when the resistance is increased?
  - How does this differ from using gears to control speed?
- **Student Activity:** Students to undertake the demonstrated electronic activities that demonstrate the flow of electrons and how these can be used to create light, cause motion, and control speed (see resources list).
- **Teacher Demonstration:** Teacher demonstrates fault finding processes on a simple circuit.
- **Student Activities:** Teacher demonstrates fault finding processes on a simple circuit.
  - Students to demonstrate their knowledge in circuit fault finding challenges on TinkerCAD.
  - Students to begin their challenge to perform a specific motion task with 3V battery and components as discussed in the previous lesson.
- **Video 3.8.3:** Watch the video to think about how an engine works. For homework, think about how an electric motor could be used to power a car.

Topic 3

Applying the learning – a design challenge using renewable energy

Inquiry Question 3: What design approach is more efficient at moving a model Kombi 20 metres?

Lessons 8 & 9 Resources

- **Teacher Demonstration Resources**
    - Energy source: 3V and 9V batteries
    - Switches slide / momentary switches
    - Motors
    - Gears
    - LEDS
    - Resistors
    - Variable resistors
    - Capacitators
    - Fans
    - Multimeters
- Video 3.8.1: The Batteries Used In An Electric Vehicle Erich Wittstock, Technical and Laboratory Manager at Southern Cross University, and Andy Naughton, engineering alumni from Southern Cross University, discuss the different types of batteries used in devices compared to the Kombi.
- Video 3.8.2: A comical take on the situation with batteries in electric vehicles.
- TinkerCAD
- **Student Activity Resources**
    - Energy source: 3V batteries.
    - Switches slide / momentary switches.
    - Motors
    - Gears
    - LEDS
    - Resistors
    - Variable resistors
    - Capacitators
    - Fans
- Video 3.8.3: How does an Electric Motor work? (DC Motor)

Topic 4

Student design portfolios – applying thinking to design processes

Inquiry Question 4: How can we document our thoughts and decisions in the development of the model Kombi?

6.2 Technologies related to motion:

- gyroscopes
- accelerometers
- sensors

Students learn to:

- Describe how various technologies related to motion function
- Apply various motion technologies to the design of student projects

Lessons 10, 11 & 12:

- **Teacher instructions:** Discussion on the expectations of the layout and content of a student design portfolio. Examples to include opportunities and evidence of:
    - **Divergent thinking** with simple sketches with annotations. The mini torch example illustrates the use of annotations to highlight design features and ideas.
    - **Convergent thinking** such as PMIs/ pros/cons comments that justify design decisions. The guitar project demonstrates the use of PMIs (Plus, Minus, Interesting) to assist in the decision-making process.
- **Student design portfolio construction:** Students to create a design portfolio journaling the Kombi design and development of the ideas into a prototype.
    - Whilst the project is to be completed in pairs, each student completes a portfolio for assessment.

Lessons 10, 11 & 12 Resources

- **Teacher instructions:** link to examples of student design portfolios (Teachers use their own exemplars or link to those from ACARA – see example below).
- Understanding the difference between Divergent and Convergent thinking (visual representation)
- Example of a simple sketch: a mini torch project
- Example of a simple sketch and Plus Minus Interesting tool for decision making: the electric guitar project
- Example of a Student Design Portfolio: the jewellery project

STEM Process
5. PROTOTYPE

Topic 5

Introduction to CAD design – developing a prototype (electronics)

Inquiry Question 5: How is CAD a beneficial tool for designing and engineering solutions?

6.1 Electronics
Students learn about:
- practical applications

Students learn to:
- Develop prototypes using a variety of materials to simulate motion produce models in order to solve problems related to motion

Lesson 13, 14 & 15:

- **Student Design Challenge:** Designs have progressed to a stage where they can be documented formally and in detail. These lessons also present opportunities for modelling the design. There are two types of drawing and modelling here:
  - **For the body of the Kombi and**
  - **For the circuit.**

Process for drawing and modelling the Body of the Kombi:
- **Teacher demonstration:** presentation of final designs on CAD including dimensioning.
- **Video 5.15.1: The Engineering And Technology Design Process** The benefits of using CAD in STEM projects through an example with the **Kombi project.**
- **Student activities** (conducted in TinkerCAD or using isometric hand-drawings):
  - Design is drawn in 3D.
  - Design is presented assembled as a 2D orthogonal drawing with dimensions.
  - Students to document final design templates in CAD.
  - Drawings must be fully dimensioned!

Process for drawing and modelling the Circuit:
- **Teacher demonstration:** Teacher models the use of CAD application of choice or TinkerCAD to demonstrate common components or those useful to the design task:
  - Demonstrate component library
  - Assembly of circuit
  - Simulation of circuit
  - Manipulation of components, or change of component values
- **Student activities:**
  - Students practise electronics knowledge and skills development through simulating circuits on TinkerCAD.
  - Students to simulate the function of the circuit using the TinkerCAD simulator.
  - Students to evaluate efficacy of circuit to create motion. Students to work on circuit refinement in TinkerCAD until desired outcome is simulated. This can be achieved using the multimeter to check amperage and suitable resistors.

STEM Process
5. PROTOTYPE

Topic 5

Introduction to CAD design – developing a prototype (electronics)

Inquiry Question 5: How is CAD a beneficial tool for designing and engineering solutions?

Lessons 13, 14 & 15 Resources

- CAD of choice
- Video 5.15.1: The Engineering And Technology Design Process Engineering Student Max Den Exter from Southern Cross University highlights the benefits of using CAD in STEM design work (start @ 2:25min)
- Example: Part of a 3D model in SketchUp
- Example of a 2D orthogonal drawing with dimensions

Resources for drawing and modelling the Circuit:

- TinkerCAD
- **Teacher demonstration.** Use the following components:
    - Multimeter
    - Motor
    - LED
    - Resistor and potentiometer
    - 3V or 9V battery

STEM Process
3. BRAINSTORM

Topic 6

Understanding car engines – gyroscopes, accelerometers, sensors (technologies related to motion)

Inquiry Question 6: How can the integration of technologies such as the micro:bit be used to improve the functionality and efficiency of the Kombi vehicle?

6.5 Developing projects related to motion
Students learn to:
- Apply problem solving techniques to identified problems related to motion
- Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion

Lesson 16

- **Teacher demonstration:** the micro:bit and how it can be used.
  - **Key Question:** Can the sensors on the micro:bit be used to collect data?
  - Accelerometer
  - Speed
- **Student Activity:**
  Students use a gyroscope to explore the concepts of angular motion and torque by performing a number of simple activities using the examples in the video.
- **Student Activity:**
  Students to make a 2-minute video to explain the concepts of angular motion, torque and functionality of a gyroscope using their model and demonstrating one or more of the activities.
- **Teacher Demonstration and Discussion:**
  - The process of using code and the hardware needed to capture data.
  - The process of how to collect and analyse data.
- **Student Activity:** Students to investigate data capture using a micro:bit.
  - **Key Question:** What data is being collected and for what purpose?

Lessons 16 Resources

- Micro:bit crash course
- First steps with microbits for data-logging and modelling
- Accelerometer
- Micro:bit and accelerometer resource
- Getting two microbits to talk to each other
- Teacher demonstration and discussion:
  Teachers can use this activity or for example, a speed trial of the electric Kombi from point a to point b as an example for demonstration. It requires the use of two micro:bits for collecting and analysing data. Further resources depend on the microcontroller used such as a microbit or an Arduino. But for the microbit, refer to the makecode site
- Student Activity: Gyroscopes
- Micro:bit & gyroscopes

STEM Process
3. BRAINSTORM

Topic 6

Understanding car engines – gyroscopes, accelerometers, sensors (technologies related to motion)

Inquiry Question 6: How can the integration of technologies such as the micro:bit be used to improve the functionality and efficiency of the Kombi vehicle?

Lessons 17 & 18

- **Teacher demonstration:** Teacher toprovide coding tutorials for students topractise the content.
- **Student Activity:** This is a continuation of Lesson 16, where students are investigating data capture with the use of a micro:bit. To achieve this, students are developing confidence and competence in visual or general purpose coding. Students to work through coding exercises to program micro:bits to collect acceleration data. Teacher to facilitate application of skills and knowledge to develop functional code for their vehicle projects. Students to test their code to determine if the code is functional.

  See resources from lesson 16.

STEM Process
6. EVALUATE

Topic 7 Data analysis and prototype testing

Inquiry Question 7: How can the use and analysis of data, enable more efficient and more effective designs?

6.4 Motion calculations
Students learn about:

- velocity
- acceleration
- inertia
- circular motion
- momentum

Students learn to:

- Apply mathematical and graphical methods to solve motion related problems involving velocity, acceleration, inertia, circular motion and momentum
- Determine solutions to simple problems related to motion perform simple calculations related to momentum

6.5 Developing projects related to motion
Students learn to:

- Apply problem solving techniques to identified problems related to motion
- Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion

Lesson 19

- **Acceleration data analysis:** Students learn how to use the data collected through the testing process (see Accelerometers Resources).
- **Teacher demonstration:** Teacher to demonstrate data collection and analysis using an exemplar project.
- **Student Activity:** Students to replicate data collection and analysis in pairs using their micro:bits.
  - **Key Questions:** What data is to be collected using the micro:bit accelerometer?
  - What code would be used to collect the data from the moving vehicle?
- **Student Activity:**
  Students plan how the acceleration data will be collected and analysed. Students test the practical components and collate data on the variables from the tasks. Students improve testing procedures to improve speed.
- **Key Questions:**
  - How data will be collected using the micro:bit accelerometer?
  - What code would be used to collect the data from the moving vehicle?
- **Student Activity:** Students evaluate their use of the micro:bit accelerometer.
  Key Questions:
  - In student science notebooks, explain what the tests demonstrated?
  - What improvements could be made to improve the speed?
  - Share the data with other groups –what were the differences between the groups?
  - Were there a variety of variables to consider?

Lesson 19 Resources

- **Acceleration** Suggest use of microcontrollers attached to the vehicle to collect data.
- Timing Gates
- Micro:bit and MakeCode

Topic 7

Data analysis and prototype testing

Inquiry Question 7: How can the use and analysis of data, enable more efficient and more effective designs?

Lesson 20

- **Circuit 'dry' assembly.**
- **Teacher demonstration:** What is expected in the temporary assembly of the circuit to allow for modification or fault correction.
- **Student Activity:** Students to collect and assemble components using temporary methods such as breadboard.

Lesson 20 Resources

- TinkerCAD
- Breadboard
- Electronic components

Lesson 21

- Students to complete and test circuit design for function. Time is allocated for modification to ensure circuit operation is optimal.

Lesson 21 Resources

- Established design criteria to be used to determine functionality and efficacy from Lesson 4

Southern Cross University

STEM Process 6. EVALUATE

STEM Process 5. PROTOTYPE

Topic 8

Car development, manufacture, testing and improvement

Inquiry Question 8: How can the properties of a material (e.g. cardboard) be harnessed or adapted to improve the efficiency of the Kombi vehicle?

6.4 Motion calculations
Students learn about:

- velocity
- acceleration
- inertia
- circular motion
- momentum

Students learn to:

- Apply mathematical and graphical methods to solve motion related problems involving velocity, acceleration, inertia, circular motion and momentum
- Determine solutions to simple problems related to motion perform simple calculations related to momentum

6.5 Developing projects related to motion
Students learn to:

- Apply problem solving techniques to identified problems related to motion
- Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion

Lesson 22, 23 & 24

- **Teacher demonstration:** showing the safest and most accurate method for creating the NET development of the cardboard template to create:
  - Chassis
  - Body
- **Note:** The chassis must be able to accommodate electronic driving mechanism. It is intended that the body template is designed to fold up and to fit over the chassis.
- **Student Activity:** Students to use a cardboard sheet to create a template and to make the vehicle.
- **Teacher demonstration:** Cardboard performance characteristics. Teacher demonstrates areas of concern regarding cardboard performance.
  - Examples include: lamination of cardboard layers, or using glued timber ribs.
  - Could waterproof with wax, tape, examples from nature?
- **Class discussion:** How could you improve the properties of the material?
- **Student Activity:** Students to investigate ways to change the properties of cardboard and the design of the vehicle to make it stiffer, waterproof and more durable.

Lesson 22, 23 & 24 Resources

- Cardboard
- Marking out and cutting equipment
- Could be drawn in CAD and cut out. Suggest only making body to fit on top of chassis. Maybe solar cells could sit on roof. See cardboard Kombi template attachments.
  Example 1
  Example 2

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STEM Process
7. ITERATE

STEM Process
6. EVALUATE

STEM Process
5. PROTOTYPE

Topic 9

Cardboard Kombi Testing and Evaluation

Inquiry Question 9: How can the processes of testing and evaluation enable more efficient and more effective, and functional designs?

6.5 Developing projects related to motion
Students learn to:
- Apply problem solving techniques to identified problems related to motion
- Plan,implement and evaluate a sequence of operations for the completion of a design project related to motion

Lesson 25, 26 & 27

- **Teacher Demonstration and Discussion:** Teacher models safe working procedures for the accurate cutting of cardboard. Teacher to discuss the booking and use of the test track.
- **Student activities:**
  - Students to use available technology and safe cutting practices to cut out cardboard template.
  - Students to assemble prototype to prepare for preliminary testing.
  - Prototype testing.
  - Students to develop model and test on designated track.
  - Evaluation: Students to journal problems and opportunities for refinement.
  - **Key Questions:** Refer back to the Lesson 4 criteria. Does the design need to improve its performance? e.g., more aerodynamic? More efficient?

Lesson 25, 26 & 27 Resources

- Ensure safety testing is completed.
- Laser cutter or scalpels.
- Resources: Equipment for assembly.
- A decision on the distance and track would need to be made. This to be informed by criteria developed in lesson 4.
  - How could the micro:bit collect data here? Recall:
  - Lesson 19: timing gates
  - Lesson 16: rocket acceleration
  - A different take on acceleration

Southern Cross University

STEM Process
8. COMMUNICATE

Topic 10

Cardboard Kombi Testing and Evaluation part 2

Inquiry Question 10: How does the engagement in integrated STEM projects prepare students for a future in STEM-related industries?

6.4 Motion calculations
Students learn about:

- velocity
- acceleration
- inertia
- circular motion
- momentum

Students learn to:

- Apply mathematical and graphical methods to solve motion related problems involving velocity, acceleration, inertia, circular motion and momentum
- Determine solutions to simple problems related to motion perform simple calculations related to momentum

6.5 Developing projects related to motion
Students learn to:

- Apply problem solving techniques to identified problems related to motion
- Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion

Lesson 28, 29 & 30

- **Teacher instructions:** Teacher explains the rules and event day program to teams.

- **Student activities:**
  - Final testing:
  - All data is captured and submitted to cloud document scoreboard for comparative analysis.
  - Collection and analysis, and synthesis of statistics and to upload statistics onto scoreboard.

- **Teacher Demonstration:** Teacher to demonstrate the analysis of the raw ‘event day’ data.

- **Student Activities:**
  - Students to analyse event day data and graph the acceleration and velocity of their vehicle
  - Students to evaluate vehicle design and submission of portfolio to the teacher.

- **Teacher Demonstration and Discussion:** Teacher to present comparison of data across all vehicles. Discussion on their performance in relation to theoretical vs actual results.

- **Video 10.30.1: Careers In Stem** Dr Maree Lake, a senior lecturer and civil/traffic engineer from Southern Cross University, discusses the path to becoming an engineer and the varied and unique opportunities that exist for careers in engineering. This video promotes the STEM subjects and women in STEM and engineering.

- Students to reflect back on the electric Kombi unit has transformed their understanding of the concepts of energy use, sustainability, prototyping and motion

STEM Process
COMMUNICATE

Topic 10

Cardboard Kombi Testing and Evaluation part 2

Inquiry Question 10: How does the engagement in integrated STEM projects prepare students for a future in STEM-related industries?

Lesson 28, 29 & 30 Resources

- **Background organisation:** A flagstone event to showcase the work of the students through the unit. Ensure event day organisation has been planned. Event day book program is published.
- Create a cloud scoreboard document using an online application such as Google Sheets or online Microsoft Excel to be made available for students to upload data. This enables the students to compare data for acceleration, speed etc. easily and accessibly.
- Example of measuring constant velocity
- Design portfolio submission
- Presentation of data from cloud doc. and data analysis.
- Video 10.30.1: Careers In Stem Dr Maree Lake (SCU) talks about careers in engineering from the STEM subjects
- SCU Reflective writing quick guide

Map of tasks through the weeks of the project

Tasks	Week 1			Week 2			Week 3			Week 4			Week 5			Week 6			Week 7			Week 8			Week 9			Week 10		
Oil production and pollution content	●																													
Oil use & combustion engines	●																													
Motion and simple machines		●																												
Renewable energy use as an alternative approach			●																											
Brief & brainstorming				●																										
Students learn about electricity					●	●																								
Prototype design							●	●	●																					
Prototype design finalisation										●	●																			
Circuit design and simulation on TinkerCAD												●	●																	
Students learn about micro:bit and sensors such as the accelerometer														●																
Coding and testing of accelerometer															●	●														
Acceleration analysis																	●													
Circuit assembly																		●												
Circuit testing & modification																		●	●											
Vehicle template design																				●	●	●								
Vehicle construction and assembly																							●	●	●					
Preliminary vehicle testing & modification																										●	●			
Final vehicle testing event																												●		
Collation of statistics																													●	
Analyse vehicle stats																													●	
Evaluate vehicle design																														●
Comparison between all vehicles																														●
Unit reflection																														●

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Map of tasks through the weeks of the project

Students learn about:	Students learn to:	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8	Topic 9	Topic 10
6.1 Electronics • circuitry • motors & generators • fault detection • prototypes • making models • practical applications	Design and construct basic electronic circuitry		●								
	Develop basic motors and generators		●								
	Use fault diagnosis techniques to isolate problems		●								
	Use multimeters to test circuits and components		●								
	Use continuity testers/multimeters in the production and testing of practical projects		●								
	Develop prototypes using a variety of materials to simulate motion produce models in order to solve problems related to motion		●			●		●	●		
6.2 Technologies related to motion • gyroscopes • accelerometers • sensors	Describe how various technologies related to motion function				●						
	Apply various motion technologies to the design of student projects				●			●	●		
6.3 Energy • energy sources • motors • electric vehicles • motion	Identify and describe a range of energy sources including renewables and non-renewables	●		●							
	Utilise electric motors to develop a project related to motion			●							
	Select and use a range of components and hardware in the development and production of a practical project related to			●				●	●		
6.4 Motion calculations • velocity • acceleration • inertia • circular motion • momentum	Apply mathematical and graphical methods to solve motion related problems involving velocity, acceleration, inertia, circular motion and momentum							●	●	●	●
	Determine solutions to simple problems related to motion perform simple calculations related to momentum							●	●	●	●
6.5 Developing projects related to motion	Apply problem solving techniques to identified problems related to motion						●	●	●	●	●
	Plan, implement and evaluate a sequence of operations for the completion of a design project related to motion						●	●	●	●	●

Exemplar model Kombi body: the how-to guide

1

[Printable template]

2

3

Option one: Draw your own template up on CAD. Print this out to paste onto cardboard. **Option two:** Use the link right to print an example of a model Kombi.

Once you have printed out the template, it is at this point that you may consider whether you intend to colour in the template or not. One solution is to use coloured contact instead of markers to colour the Kombi.

The body of the Kombi needs to be light. Consider the thickness of cardboard that may be suitable. In the example, ice block packaging provided a thin, yet sturdy piece of cardboard that was big enough for the printed template.

This one could be difficult for the left handers. Cut around the template. Depending on what your plan is, the wheels can also be cut away.

Once it has been cut out, begin by folding up the tabs before you fold up the sides, back and front.

Exemplar model Kombi body: the how-to guide

4

In this example, the intention was to make a chassis that would be strong enough to house any electronic components, a motor, batteries and a gearbox.

To achieve this, we repeated with a chassis template that was designed to fit inside the folded-up body. Again, this could be drawn up using CAD. In this example we decided that a pizza box would provide us with the strength we needed. The photo on the right shows how the chassis was designed to fit inside the body.

As the chassis has two long folds, the intention was to provide a was to secure the body to the chassis. Self-tapping screws may be suitable.

5

Depending on your intentions, you may have other wheels and axles in mind.

If you wanted to continue down the reuse path, we have provided some examples of the types of items you may have lying around that could be useful.

What ideas do you have?