**Solar Car Challenge**

## Summary

This unit provides students with the opportunity to investigate the principles behind electric vehicles, their role in reducing carbon emissions and the importance of finding alternative energy sources to drive the transport industry. They will extend their learning to gain insights into innovative applications of electric vehicles as mobile power sources that can be used to power domestic and commercial premises. Students will develop an understanding of electric motors and investigate key concepts related to motion.

Students will use the iSTEM process to develop a solution to the Solar Car Pursuit Challenge and integrate the use of technology to analyse aspects of the vehicle’s motion.

## Duration

10 weeks 2.5 hours/week

## Outcomes

* **5.1.1** develops ideas and explores solutions to STEM based problems
* **5.2.1** describe how scientific and mechanical concepts relate to technological and engineering practice
* **5.2.2** applies cognitive processes to address real world STEM based problems in a variety of contexts
* **5.3.1** applies knowledge and understanding of STEM principles and processes
* **5.3.2** identifies and uses a range of technologies in the development of solutions to STEM based problems
* **5.4.1** plans and manages projects using an iterative and collaborative design process
* **5.4.2** develops skills in using mathematical, scientific and graphical methods whilst working as a team
* **5.5.1** applies a range of communication techniques in the presentation of research and design solutions
* **5.5.2** critically evaluates innovative, enterprising and creative solutions
* **5.6.1** selects and uses appropriate problem solving and decision-making techniques in a range of STEM contexts
* **5.6.2** will work individually or in teams to solve problems in STEM contexts
* **5.8.1** understands the importance of working collaboratively, cooperatively and respectfully in the completion of STEM activities

[iSTEM School Developed Board Endorsed Course (2016)](https://sispprogram.schools.nsw.gov.au/content/dam/doe/sws/schools/s/sispprogram/stem/iSTEM-Syllabus-V3-7_10_16.pdf) © NSW Department of Education for and on behalf of the Crown in right of the State of New South Wales, 2016.

## Unit overview

Students develop an understanding of energy sources and how these relate to circuitry and the use of motors and generators. Students research electric vehicles and how they are contributing to businesses being able to build carbon neutral fleets. Students investigate the workings of electric motors and apply this knowledge in the design and construction of a solar car. Additionally, students will research and test variables related to vehicle design such as aerodynamics and gearing. They then apply this learning to examine the benefits and limitations of solar vehicles and investigate broader applications of electric vehicles. Students develop a portfolio to demonstrate their learning and application of the iSTEM process to answer the key inquiry question.

## Key Inquiry Question

Why is the popularity of electric vehicles (EV) on the rise and will this trend continue?

## Resources

* Munich Airport’s movement to a carbon neutral fleet - [munich-airport.com/electric-vehicles-at-the-airport-5938664](https://www.munich-airport.com/electric-vehicles-at-the-airport-5938664)
* Newcastle’s support and use of electric vehicles - [newcastle.nsw.gov.au/council/news/latest-news/city-prepares-for-electric-vehicle-future](https://www.newcastle.nsw.gov.au/council/news/latest-news/city-prepares-for-electric-vehicle-future)
* STELR Solar Car [Curriculum Materials](https://stelr.org.au/stelr-modules/solar-cars/)
	+ Solar car challenge booklet (pdf)
	+ Mathematics of gears workbook (pdf)
* Components of an electric circuit - [hunker.com/12003706/the-four-and-more-basic-parts-of-an-electrical-circuit](https://www.hunker.com/12003706/the-four-and-more-basic-parts-of-an-electrical-circuit)
* What is a circuit? - [vimeo.com/456137874](https://vimeo.com/456137874)
* Simple homemade continuity tester - [youtube.com/watch?v=hQaPE1FMn58](https://www.youtube.com/watch?v=hQaPE1FMn58)
* Correct use of a multimeter - [vimeo.com/456122918](https://vimeo.com/456122918)
* How fuses work - [spark.iop.org/how-fuses-work#gref](https://spark.iop.org/how-fuses-work%23gref)
* How DC motors work - [vimeo.com/456155789](https://vimeo.com/456155789)
* How to make a simple DC motor - [vimeo.com/456078778](https://vimeo.com/456078778)
* SISP secondary solar car challenge pursuit solar car rules and regulations (pdf)
* API STELR solar-powered car instructions - [australiascience.tv/episode/api-stelr-solar-powered-car-instructions](file:///C%3A%5CUsers%5Csleap%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CINetCache%5CContent.Outlook%5CBMFTHTH3%5Caustraliascience.tv%5Cepisode%5Capi-stelr-solar-powered-car-instructions%5C)
* API STELR solar car: how to change the gears - [australiascience.tv/episode/api-stelr-solar-powered-car-how-to-change-the-gears](https://australiascience.tv/episode/api-stelr-solar-powered-car-how-to-change-the-gears/)
* Gear ratios - [vimeo.com/456045469](https://vimeo.com/456045469)
* Pursuit solar mini EV intro - [vimeo.com/444421518](https://vimeo.com/444421518)
* Pursuit solar mini EV wheels & gears - [vimeo.com/444421620](https://vimeo.com/444421620)
* Pursuit solar mini EV wiring - [vimeo.com/444421295](file:///C%3A%5CUsers%5Csleap%5CAppData%5CLocal%5CMicrosoft%5CWindows%5CINetCache%5CContent.Outlook%5CBMFTHTH3%5Cvimeo.com%5C444421295)
* Pursuit solar EV construction - [vimeo.com/444421081](https://vimeo.com/444421081)
* Pursuit solar EV kit variation & ideas - [vimeo.com/444421200](https://vimeo.com/444421200)
* Gyroscopes and accelerometers worksheet (pdf)
* Phyphox app - <http://phyphox.org/>
* World solar car challenge - [worldsolarchallenge.org/](https://www.worldsolarchallenge.org/)

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| Content | iSTEM outcome | Teaching and Learning | Evidence of Learning | Adjustments and registration |
|  | 5.1.15.2.1 | **Inquiry question:**Why is the popularity of electric vehicles (EV) on the rise and will this trend continue?**Teacher**Examine [Munich Airport’s movement to a carbon neutral fleet](https://www.munich-airport.com/electric-vehicles-at-the-airport-5938664) or [Newcastle’s support and use of electric vehicles](https://www.newcastle.nsw.gov.au/council/news/latest-news/city-prepares-for-electric-vehicle-future) to discuss what is driving investment into the development of electric vehicles. This might include:* global carbon emissions
* sustainable energy sources
* performance of batteries
* increased range of recharge options
* innovative applications of car batteries, for example off-grid electricity.

**Students**Research and analyse information in relation to the use of electric vehicles and solar charge stations to reduce carbon emissions. | Students show understanding of the effects of carbon emissions and the need to reduce themStudents demonstrate an understanding of the contribution electric vehicles can make to reducing global emissions.Students can make connections between how technologies can be applied to solve environmental challenges. |  |

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| Content | iSTEM outcome | Teaching and Learning | Evidence of Learning | Adjustments and registration |
| 6.3 energyenergy sources | 5.2.1 | **Teacher and students**Identify energy sources as either renewable or non-renewable. For example:* wind
* solar
* geothermal
* nuclear
* coal.

Discuss the advantages and disadvantages of different energy sources used in the production of electricity.Investigate how some of the shortfalls of renewable energy are being rectified. For example, solar does not generate electricity at night when demand is high, but this can be supplemented by storing surplus energy generated during the day using battery technology as demonstrated by Horsdale power reserve. | Students correctly identify a range of energy sources as renewable or non-renewable.Students can distinguish between what makes a resource renewable or non-renewable.Students can describe a range of energy sources, and correctly identify advantages and disadvantages related to their use for production of electricity. |  |
| 6.3 energyenergy sources | 5.2.1 | **Students**Explore various energy transfers and transformations.* power stations: kinetic  electrical + heat
* batteries: chemical 🡪 electrical
* motors: electrical  kinetic + heat
* electricity grid networks
 | Students can demonstrate the transfer of energy in simple and complex energy sources using flow diagrams. |  |
| 6.3 energyenergy sources | 5.2.1 | **Students**Investigate the function of photovoltaic cells by using a multimeter to measure the open voltage (Voc) and short circuit current (Isc) of a solar panel.Demonstrate their understanding of the conversion of light energy to electrical energy in solar cells by varying the light intensity hitting the photovoltaic panels.Students record the results of their investigation in their engineering journals for later use.Additional information can be found in the [STELR Solar Car Challenge](https://stelr.org.au/stelr-modules/solar-cars/) booklet (pages 15-19). | Students can demonstrate their understanding of how photovoltaic cells work using the correct terminology in written and verbal responses.Students use tables to display information about the relationship of light intensity to open voltage or short circuit current. |  |
| 6.1 electronics* circuitry
* fault detection
 | 5.2.15.6.1 | **Teacher**Describe the four main [components of an electric circuit](https://www.hunker.com/12003706/the-four-and-more-basic-parts-of-an-electrical-circuit) - energy source, conductor, electrical load, controller.**Teacher and students**Watch the video clip [what is a circuit](https://vimeo.com/456137874) (duration 5:45) as a class.**Students**Construct basic circuits using available resources. For example:* series
* parallel
* combined series and parallel.

Construct a continuity tester using a side by side battery holder, a 3-volt buzzer and two probes. Or this [simple homemade continuity](https://www.youtube.com/watch?v=hQaPE1FMn58) tester. | Students can draw diagrams of simple circuits using correct symbols.Students can explain the difference between conventional current and electron flow.Students can construct simple electrical circuits and explain their function. |  |
| 6.1 electronics* fault detection
 | 5.2.15.6.1 | **Teacher**Demonstrate the [correct use of a multimeter](https://vimeo.com/456122918) and explain how it can be used for fault detection.Discuss the likely causes and locations of faults in a circuit. For example:* broken wire
* faulty power source
* faulty load.

**Students**Construct a circuit with a light, switch and [fuse](https://spark.iop.org/how-fuses-work#gref). Use a multimeter to examine voltage drops across different components in this circuit.Create a short circuit to overload the fuse, then examine how the multimeter could be used to detect the fault.Use the continuity tester to test the circuit. | Students are able to safely and competently construct simple electrical circuits and analyse their characteristics using a multimeter.Students can describe the process of simple fault detection in electric circuits. |  |
| 6.1 electronics* motors & generators

prototypes* making models
* practical applications
 | 5.1.1 | **Teacher**Provide commercial models of simple motors and generators for students to examine.**Students**Identify the main components in the models (coil, commutator, brushes and magnets)Examine [how motors work](https://vimeo.com/456155789).Construct a [simple DC electric motor](https://vimeo.com/456078778).Analyse and explain the difference between a motor and a generator.Identify applications of electrical motors. | Students can describe the conversion of electrical energy to kinetic energy in electric motors.Students successfully construct a simple working model of an electric motor and explain how it works. |  |
| 6.3 energy* motors
 | 5.2.1 | **Students**Describe energy transfers and transformations in motors and generators.* Motors: electrical  kinetic + heat
* Generators: kinetic  electrical + heat
 | Students demonstrate prior learning to construct flow diagrams representing energy transformations in motors and generators.Students demonstrate an understanding that the principles of motors and generators are the reverse of each other through verbal and written responses. |  |
| 6.3 energy* motors
* electric vehicles
* motion

6.5 developing projects related to motion | 5.1.15.1.25.3.15.4.15.5.15.6.25.8.1 | **Teacher**Provide students with either the Pursuit Solar Car Challenge rules and regulations or STELR Solar Car resources and organise students into groups to participate in one of the challenges.**Students**Work in groups with agreed, allocated and identified roles to use the iSTEM design process to develop a solar car to meet the requirements of the challenge.Develop a portfolio showing evidence of testing different solutions related to factors such as gear ratios, guide systems, drive type and aerodynamics.Watch the video on [gear ratios](https://vimeo.com/456045469).Complete relevant parts of the Mathematics of Gears workbook to record their calculations regarding the gearing of their solar car.Use Instructional videos to assist their design process:* [pursuit solar mini EV – intro](https://vimeo.com/444421518)
* [pursuit solar mini EV - wheels & gears](https://vimeo.com/444421620)
* [pursuit solar mini EV - wiring](https://vimeo.com/444421295)
* [pursuit solar EV - construction](https://vimeo.com/444421081)
* [pursuit solar EV kit - variation & ideas](https://vimeo.com/444421200)

Perform time trials and record data relating to the performance of their solar car using different design elements. | Students can articulate the scope and parameters of the selected challenge including the associated constraints.Students demonstrate the use of the iSTEM design process in a portfolio addressing each stage of the process as it relates to the overall challenge.Students produce a working solar powered car. |  |
| 6.5 developing projects related to motion | 5.4.1 | **Students**Record evidence of all prototypes, trials and data collection from the above activities in an engineering journal. | Students produce a portfolio showing a complete record of their learning throughout the tasks. This portfolio may make use of various media, for example: * text and images
* video production
* stop motion animation.
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| 6.4 motion calculations* velocity
* acceleration
* inertia
* circular motion
* momentum
 | 5.2.15.3.15.4.2 | **Teacher**Define and explain motion related terms:* distance
* displacement
* speed
* velocity
* acceleration
* inertia
* momentum
* circular motion (extension).

Explain the data required to solve motion related problems:* instantaneous versus average velocity (displacement/time)
* average acceleration (a= (v-u)/t)
* inertia related to varying mass
* momentum ρ = mv
* circular motion and the forces involved on a race circuit.

Provide example problems for students to solve qualitatively, mathematically and graphically.**Students**Apply mathematical and graphical methods to solve motion related problems involving speed, velocity, acceleration and momentum.Determine solutions to simple problems related to motion.Perform simple calculations related to momentum.Develop methods to collect measurements in order to calculate the acceleration, maximum velocity and momentum of their solar car.Analyse the forces on their car taking into account factors which may include:* guide systems used on circular pursuit track
* mass of vehicle
* contact between wheels and track surface.
 | Students can solve quantitative and qualitative motion-related problems.Students can identify data that needs to be collected to calculate motion-related quantities of their solar cars.Students collect data and perform calculations related to the motion of their solar cars. |  |
| 6.2 technologies related to motion* accelerometers
* sensors
 | 5.3.2 | **Teacher**Demonstrate the use of a Micro:Bit to collect data through its accelerometer and light sensor.**Students**Investigate the use of the Micro:Bit accelerometer to collect data about the solar car’s motion.Use the light sensor on the Micro:Bit to analyse the effect of light intensity on the performance of the solar car under a range of conditions – sunny day, cloudy day, under the shade of a tree. | Students can use data to describe the changing motion of their car as it completes the pursuit track. |  |
| 6.2 technologies related to motion* gyroscopes

6.5 developing projects related to motion | 5.1.15.1.25.2.15.3.25.4.2 | **Extension (Optional):****Teacher**Demonstrate a spinning top as a simple gyroscope.Explain how a gyroscope works to maintain or measure orientation and angular velocity.The Gyroscopes and Accelerometers worksheet will assist.**Students**Download and use a mobile phone app that allows for the collection of data from the phone’s gyroscope. For example* Physics Toolbox Sensor Suite
* Physics Toolbox Gyroscope
* [Phyphox](http://phyphox.org)

Design strategies to experiment with mounting the phone to the car to collect data and describe the changing velocity of the solar car both in test scenarios and as it completes the race track.Identify uses of gyroscopes in vehicles.Design modifications to the solar car to implement steering and enable it to be controlled by using the gyroscope of another device, for example a phone or Micro:Bit. | Students integrate technologies into their solar car project in order to collect and present data describing the motion of their solar car. |  |
| 6.5 developing projects related to motion | 5.1.15.2.15.2.25.3.1 | **Teacher**Lead discussion with students about the use of models or prototypes in STEM. Facilitate discussion about the solar car models in terms of:* benefits (price, simplicity, ability to test design aspects and performance).
* limitations (no variable gear box, not reflective of needing a driver/passengers)

**Students**Research full scale examples of solar cars such as those used in the [world solar car challenge](https://www.worldsolarchallenge.org/) and describe the limitations of these vehicles. Aspects to consider could include:* light conditions
* night driving
* space for passengers.

Explore and propose design concepts for solar-powered electric vehicles based on human needs and scientific and engineering principles. | Students can describe what a model is and the purpose of using models as well as their advantages and limitations.Students can describe, through verbal and written responses, the purpose of solar vehicles, while analysing the practical difficulties associated with them.Students produce a proposal that demonstrates understanding of human needs in a vehicle and links these with the scientific and engineering principles learnt throughout the course. |  |
| 6.5 developing projects related to motion | 5.1.15.5.2 | **Teacher**Facilitate discussion around the place of solar in the EV industry, including:* solar panels integrated into vehicle design
* home solar charging stations
* commercial solar charging stations

**Students**Research the practicality of domestic and commercial solar charging stations.Analyse the use of electric vehicles as an off-grid power source for domestic and commercial premises. Examine both V2H (vehicle-to-home) capability and V2G (vehicle-to-grid) capability. | Students participate in discussions about the practicality of this technology in real world scenariosStudents can describe the role of solar in the EV industry as part of reducing global emissions.Students can analyse the innovative applications of EVs as portable batteries and articulate current limitations of these applications. |  |
| 6.5 developing projects related to motion | 5.2.15.5.1 | **Students**Submit their portfolio of learning, which addresses the inquiry question.Present an overview of their learning to the class. | Students can explain the reasons for the increasing popularity of EVs and give a justified prediction as to whether this trend will continue. |  |

## Evaluation

Evaluation of learning activities should be an ongoing process that happens throughout the delivery of this unit. Teachers should document their evaluation of learning activities throughout the program. The space provided below is to evaluate the overall unit of work.

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