 Stage 4 technology mandatory engineered systems

The Engineered Systems context focuses on how force, motion and energy can be used in systems, machines and structures. Students are provided with opportunities to experiment and develop prototypes to test their solutions. They learn how forces and the properties of materials affect the behaviour and performance of engineered systems, machines and structures. Knowledge of these principles and systems enables the design.

Electric Vehicles: The Dragster 25 Hours 10 Week Unit

The Dragster vehicle has been designed to provide an easy introduction to electro-mechanical devices. It is also intended that a number of dragsters can be used to compete in a class environment. This puts the additional requirement on students to investigate the effects of gearing on speed and acceleration, and to consider these factors in their vehicle design.

Outcomes

* Design and production skills TE4-1DP, TE4-2DP, TE4-3DP
* Knowledge and understanding TE4-8EN, TE4-9MA, TE4-10TS
* Related Life Skills outcomes: TELS-1DP, TELS-2DP, TELS-3DP, TELS-4DP, TELS-9EN, TELS-10MA, TELS-11TS

Resources

* Scorpio Dragster Kit or similar that includes an electric motor, battery, pinion gears and spur gears
* computer printer, digital camera (phone or other device)
* practical equipment:
  + assorted tools (e.g. small hammer, hand drill, tenon saw, scroll saw, electric drill) soldering equipment and solder, hot glue gun (unless using double sided and single sided tape), hairdryer or hot-air gun, 3-D printer (optional)
* Workbooks
  + The Dragster Teacher Guide
* Software and Online tools
  + [Equipment Safety in Schools](https://online.det.nsw.edu.au/esis/)
  + [Gear Generator](http://geargenerator.com/) (online tool)
  + [Crocodile Software](https://yenka.com/en/Yenka_Technology/)
  + [Gears simulator](https://gears-simulator.en.softonic.com/)
  + SketchUp
  + [Fusion 360-Autodesk](https://www.autodesk.com/) or similar CAD software (extension)
  + Moviemaker (or similar video editing)
* Websites
  + Kit suppliers and resources e.g. [Scorpio Technology](http://scorpiotechnology.com.au/) or similar
  + [Technology resource](http://www.technologystudent.com/) for students
  + [Learn about Batteries](http://batteryuniversity.com/learn/)
  + [Learn about Gears](http://www.technologystudent.com/gears1/gearat1.htm)
  + [Learn about gears](http://www.legoengineering.com/wp-content/uploads/2013/06/Exploring-gears-WeDo.pdf)
* Videos
  + ClickView: [Simple machines](https://online.clickview.com.au/libraries/videos/d0e0d63f-79c9-7ae2-055f-d970ae91f2d7/simple-machines-junior)
  + ClickView: [Introduction to Electricity](https://online.clickview.com.au/libraries/videos/3715243/introduction-to-electricity)
  + ClickView: [DC Motors](https://online.clickview.com.au/libraries/videos/c361b6ae-7358-0e43-b73e-546c0b0d0ee7/dc-motors)
  + ClickView: [Essential DT Skills](https://online.clickview.com.au/libraries/videos/3de75543-f584-32ef-7432-9e80b5d39d43/essentials-of-design-and-technology-skills)
  + ClickView: [Causes of Friction](https://online.clickview.com.au/libraries/series/6455121/friction/videos/6344972/causes-of-friction)
  + The Story of Science: [Power, Proof and Passion. Can We have Unlimited Power Episode 4 of 6](https://www.bbc.co.uk/programmes/b00sj736)
* YouTube
  + [Force and motion](https://www.youtube.com/watch?v=WwMiB30vh4o)
  + [Mousetrap cars](https://www.youtube.com/watch?v=mVNFxlEMWvw)
  + [Crash Course Physics # 12](https://www.youtube.com/watch?v=b-HZ1SZPaQw)
  + [Engineering Connections Formula one](https://www.youtube.com/watch?v=QC_gpr2xAjk)
  + [Give me a place to stand (Archimedes)](https://www.youtube.com/watch?v=YlYEi0PgG1g)
  + [Levers in Sport](https://www.youtube.com/watch?v=vZsyY14ObXg)
  + [Aboriginal Woomera](https://www.youtube.com/watch?v=vleudAj43tk)
  + [Biking Uphill - understanding gear ratios](https://www.youtube.com/watch?v=qacvtrh-ot8)
  + [How to make a simple motor](https://www.youtube.com/watch?v=bH7DFPIayNg)
  + [How electricity works](https://www.youtube.com/watch?v=mc979OhitAg)
  + [TED talk on how batteries work - Adam Jacobson](https://www.youtube.com/watch?v=9OVtk6G2TnQ)
  + [How to Wire the battery to the switch and motor](https://www.youtube.com/watch?v=9A1CUcbmkHo)

Register program in the last column.

| Sequence | Outcomes | Content | Suggested strategies and assessment | Resources | Registration |
| --- | --- | --- | --- | --- | --- |
| Week 1 | TE4-1DP  TE4-2DP | Develop criteria to evaluate design ideas, processes and solutions, the functionality, aesthetics and a range of constraints, e.g. accessibility, cultural, economic, resources, safety, social, sustainability, technical  Identifying and defining  Plans and manages the production of designed solutions  Develop criteria to evaluate design ideas, processes and solutions, the functionality, aesthetics and a range of constraints, e.g. accessibility, cultural, economic, resources, safety, social, sustainability, technical (ACTDEP038, ACTDIP027, ACTDIP031) DT ST | Teacher:   * provides overview of Electric car/ Dragster Unit   + classroom organisation, behaviour and safety expectations.   Students:   * complete safety testing.   Design and Production Process  Teacher:   * introduce students to the design and production process as outlined in the Technology Mandatory Syllabus Years 7-8, 2017.   + outlines major aspects of this project are the planning, design, construction, assembly and evaluation stages of the vehicle. Usage and performance, including races could be added. * explain the importance of ongoing evaluation throughout all design projects including recording progress regularly (e.g. weekly or daily basis). * distributes worksheets (. * introduces information about the calculations that will be made, problems encountered, measurements taken, and observations made. These will be used in the evaluation process. * explain assessment on progress and completion in relation to the planned timeline. * read design situation and brief. * explains the project constraints * explains that the glossary will be completed progressively throughout the unit as new concepts are learnt. * sets questions to be answered during the project:   + How do motors work?   + How do gears work?   Students:   * highlight key terms in the brief and record in workbook   + construct a vehicle to compete in a race against the other students in the class. Each student receives the same components and is to use these components to design and construct their vehicle. The vehicle is designed to travel along a fishing line 10mm above the racing surface. Each student will be given a ‘budget” for this unit. Each part and component will be given a fictitious dollar value and students will need to work carefully during fabrication and assembly to ensure they do not damage any part and are required to purchase more parts and go over budget.   + portfolio entry   Students:   * complete the cloze passage using the word bank provided.   Evaluation criteria   * as a class:   + establish evaluation criteria through brainstorming then refining to key points.   (These could include strength to weight ratio of vehicle, acceleration, speed, pulling power, cost, appearance.)  Students:   * record the evaluation criteria in portfolios. | Safety testing in accordance with Equipment Safety In Schools  Technology Mandatory 7-8 Syllabus 2017 p.22-23  Portfolio  Teacher Guide   * Section 1 * Section 2 * Section 8 |  |
| Week 2 | TE4-8EN | Investigate how force, motion and/or energy are utilised when designing engineered systems, for example: mechanisms involving simple machines | Teacher:   * introduces concepts: Engineered Systems, Force, Motion, Energy.   Students:   * brainstorm types of vehicles and determine the source of the energy for each type and how it converts the stored energy into kinetic energy (motion).   + e.g; Mouse trap car, rubber band car, Petrol engine, electric vehicle, pushbikes, dodgem cars. * write a brief report for portfolios that compares and contrasts two of these vehicles and how they use energy to produce force and motion. * construct a KML chart on components of the Engineered System. * force, energy, motion. * electricity, batteries, electric motor, gears, wheels, voltage current, resistance, power, friction, weight, wheels etc.   + portfolio entry | YouTube:   * Force and Motion * Mousetrap Cars   Websites:   * Technology student   Definitions for glossary.  KML chart |  |
| Week 3 | TE4-1DP | Designs, communicates and evaluates innovative ideas and creative solutions to authentic problems or opportunities | Teacher:   * issues kits and explains components using terminology from the KML chart. * explains the input, control, process, and output relevant to the dragster. * explains each kit as having a set cost/budget and that any extra equipment or replacement of damaged components will “cost” students.   Students:   * review the criteria for success by work out the factors that affect how fast the dragster will travel. * write up a design brief for the construction of the vehicle. * draw up a design of the vehicle, using a top view and side view. Include all necessary measurements.   + portfolio entry | Portfolio  Dragster Kits  Websites   * technologystudent * Scorpio   Teacher Guide   * Section 2 |  |
| Week 4 | TE4-8EN  TE4-9MA | Identifying and defining  Investigate needs or opportunities for designing an engineered system and investigate and select from a range of materials, components, tools, equipment and processes (ACTDEP035) DT ST  Testing and evaluating  Develop and apply testing procedures to evaluate an engineered system evaluate the effectiveness and suitability of choices made during the development and production of the engineered solution  Select and use a variety of critical and creative thinking strategies to generate innovative design ideas, for example: DT ST   * brainstorming * sketching * 3-D modelling * experimenting   Producing and implementing  Develop models, prototypes or products using a range of tools, materials and equipment to test the functionality of design ideas and consider innovative applications of advancing technologies, for example: (ACTDEP037) DT  Investigate how force, motion and/or energy are utilised when designing engineered systems, for mechanisms involving simple machines  Investigate how force, motion and/or energy are utilised when designing engineered systems, for mechanisms involving simple machines  Investigate the way Aboriginal and/or Torres Strait Islander Peoples use engineered solutions to serve community needs including those of cultural identity | The Chassis/Platform  Students:   * discuss the material properties required by a chassis.   + experiment with materials e.g. deflection (bending) under load/weights.portfolio entry   Students:   * cut disposable samples of materials: PVC, cardboard acrylic sheet, plywood, corflute etc. each 150mm x 60mm and approximately 3 to 4mm thick. * apply the same bending force to each of these samples to determine which is the strongest. * predict and rank the lightest and strongest materials. * record observations. * design an experiment to test the strength of materials that uses an accurate measurement of force. * watch Engineering Connections tensile testing of carbon fibre. * use digital scales to weigh the sample and confirm predictions. * compare bending/breaking points. Strength to weight of plywood, cardboard, acrylic etc. * recommend a material for their platform (chassis) * fabricate platform according to guidelines in student and Teacher Guides   Extension:  Students:   * model their chassis in Fusion 360 and simulate applied loads. * The double sided tape bed used to mount the motor onto the platform (chassis) could be modelled in Sketchup and 3-D printed. * Design and Make a body for the vehicle   Force  Introduction using Simple machines – Levers  (Effort, Load, Fulcrum)  Students are introduced to concepts of Force and motion through role play:  Two students on a see saw. One larger student, one smaller student represented by big F (force) and little f (force) are asked to sit at a distance from the fulcrum to put the see saw in balance (equilibrium) i.e. little force\* big Distance= big Force\* little distance: f X D = F X d.  Extension:   * students can be asked to convert mass in kilograms into newtons. * force is measured in Newtons approx. 10N=1kg. * Archimedes. Lever. “Give me a place to stand..." * [The mighty mathematics of the lever YouTube video](https://www.youtube.com/watch?v=YlYEi0PgG1g) * levers in sport: to move pole vaulters, paddles in kayaking or canoeing (addressing the misconception that it is the water the moves). * levers in the workshop using a long shifting spanner to undo a tight nut. * levers in Aboriginal tools use of a woomera to move a spear a greater distance.   + portfolio entry   Discuss the “trade off” between moving heavy objects with little force and long distance (Mechanical Advantage) and distance travelled by level (Velocity Ratio).  Teacher:   * demonstrates prototypes of mouse trap cars (and/or video clips) as stored energy (spring trap) released through a lever as kinetic energy. * Or Rubber Band Powered cars can using stored energy. | Teacher Guide   * Section 2   Engineering Connections Formula One  Websites   * Technologystudent   Teacher Guide   * Section 3   STL files available for download  Simple machines – Junior  (Highly recommended)  YouTube:   * Give me a place to stand * Levers in Sport * The Aboriginal Woomera * Mouse Trap cars   Websites   * Technologystudent   YouTube:   * Mouse Trap cars |  |
| Week 6 | TE4-8EN  TE4-10TS | Produce products or systems that apply engineering principles, for example: (ACTDEK031, ACTDEP039) DT  Examine a product that applies force, motion and/or energy for a purpose, e.g. toys, windmill  Investigate the way in which technologies evolve locally, regionally or globally and how competing factors are prioritised in the development of design solutions.  Investigate the role of an engineering professional and their impact on the environment and society | Teacher:  Introduces:   * gears & wheels. * gears as circular levers. * relationship between levers and gears. * turning forces.   Students:   * refer to see saw example; and calculate the force generated at both ends.   Force in Newtons x distance = a turning force called Torque (measured in newton metres).   * discussion and demonstration of levers repeated around an axle to make a gear or wheel.   Teacher:   * introduces pushbike experimentations include marking tooth of a gear and position on a bike wheel and taking note of the number of wheel rotations (ratios of each).   Students:   * describe the gear changes needed to ride a pushbike up hill and along a flat. * use one of the gear simulators to assist with exercises. * complete workbook exercises on gear ratios. * fabricate and assemble gears wheel and axles according to guidelines in both teacher and Portfolio entry. * draw a chart or table showing the gear ratios of their vehicle, to show how this relates to performance.   + portfolio entry   Assignment:  Investigate the advantages and disadvantages of electric vehicles.  Investigate the current developments in the production of electric vehicles around the world. | Gear generator online  Crocodile technology is a commercially available software to teach gears to enable students to investigate gears ratios and the effect of vehicle weight.  Websites:  Learn about Gears  Lego gears or geared bicycles could be used instead  ClickView or similar   * Simple machines -Junior   Portfolio  YouTube   * Biking Uphill understanding gear ratios   Teacher Guide   * Section 3.1.3 |  |
| Week 7 | TE4-8EN | Researching and planning  Investigate how force, motion and/or energy are utilised when designing engineered systems, for example: (ACTDEK031)   * electronic circuits * mechanisms involving simple machines   Generate and communicate the development of design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques.  Produce products or systems that apply engineering principles, for example:  electronic circuits designed using electrical laws  (ACTDEK031, ACTDEP039) DT | Teacher:   * introduces basic electronics (using water and hose analogy). * https://online.clickview.com.au/libraries/videos/3715243/introduction-to-electricity. * demonstrates the small electric motor from the kit wired into a simple circuit prior to assembling. * discusses the relationship between Electricity and Magnetism. * introduces Electrical Cars. * introduces Electric Motors.   Students:   * identify: voltage, current, resistance in water hose analogy. * draw electrical symbols used to represent the motor, switch and batteries. * watch TED talk on how batteries work-Adam Jacobson * explain how rechargeable batteries work. * explains how a battery produce electricity. * watch DC Motors ClickView Video. * write a brief paragraph on how DC motors work. * draw and label the components of a small motor that has been pulled apart including materials used for each component. * watch video then wire the motor to the switch. * mount the motor onto double sided tape (or 3-D printed bed). * solder the battery wires to the switch and motor according to work book instructions and video. * watch Essentials of Design and Technology Skills.   + Chapter 1&2 * complete wiring of electronics. * test connections. * mount the guide hooks according to Teacher Guide.   + portfolio entry   Extension:  Students:   * watch The Story of Science: Power, Proof and Passion Episode 4 of 6 BBC production. * research Volta, Orsted and Faraday. * describe the type of circuit used to control the dragster (series, parallel). * research Ohms law. * measure the voltage and current of the motor - work out the resistance. * find the formula used to work out power in an electric circuit. Work out the power generated by the motor.   + portfolio entry | YouTube:   * How to make a simple motor * How electricity works   Multimeter  A small electric motor pulled apart into components OR exploded view image  Documentation of experimentation in j portfolio  Website:  Learn about batteries  YouTube:   * How batteries work   TED talk   * Wire the battery to the motor and switch   Teacher Guide   * Section 4   Watch:  YouTube   * How to Wire the battery to the switch and motor   The Story of Science: Power, Proof and Passion Episode 4 of 6 BBC production  Portfolio |  |
| Week 8 | TE4-1DP | Testing and evaluating  Students:  Develop and apply testing procedures to evaluate an engineered system  Evaluate the effectiveness and suitability of choices made during the development and production of the engineered solution  Assess the solution against the predetermined criteria  Develop and apply testing procedures to evaluate an engineered system  Evaluate the effectiveness and suitability of choices made during the development and production of the engineered solution  Assess the solution against the predetermined criteria | Teacher:   * introduces race track, gates and guides according to workbooks. * develops the rules of event. * discusses Friction.   Students:   * watch ClickView Causes of Friction. * experiment with friction by placing various samples of materials onto a board and noting which slide first when one end of the board is raised. * record their observations of materials “slipperiness”. * explain what friction is. * discuss and design a measurement unit for this slipperiness (teacher introduces term co-efficient of friction). * explain how the following surfaces would affect the operation of your vehicle, and give examples of each: high friction, medium friction, low friction. * investigate the best surface within the school to run the race. Why is this so? * determine average speed, final speed (top speed), final drive ratio. * work out the RPM of wheels from data on the motor and gears used. * find out how many times the wheels turn over the race track (front and back). * weigh all the vehicles and draw a graph in relation to their performance. * work out the final “cost” of their vehicle.   portfolio entry | ClickView or similar   * Causes of friction   Timber board, protractor, sample materials e.g.  Portfolio  Teacher Guide   * Section 7 * Section 2 |  |
| Week 9 | TE4-1DP  TE4-2DP | Produce products or systems that apply engineering principles, for example: (ACTDEK031, ACTDEP039) DT   * a product that applies force, motion and/or energy for a purpose, eg toys, windmill * structures designed according to statics and properties of materials | Teacher:   * reiterates rules. * measures out track and marks each metre. * sets tape measure for section of track for video analysis. * conducts race (one stopwatch each vehicle). * charts vehicle performance name and time. * qualification rounds determine finalists.   Students:   * race and time vehicles. * film with phones &/or cameras capturing measured distance. * are permitted to fine tune vehicles before final.   + portfolio entry | Tape Measure  Start Gates, Track and Finish  Teacher Guide   * Section 6   Mobile phones or digital cameras. |  |
| Week 10 | TE4-1DP | Testing and evaluating  Develop and apply testing procedures to evaluate an engineered system  Evaluate the effectiveness and suitability of choices made during the development and production of the engineered solution  Assess the solution against the predetermined criteria | Students:   * analyse and annotate the video footage of their race including an evaluation of their vehicles performance:   + how well did the design function?   + how good was the performance?   + Did it achieve the anticipated results?   + Did the design look good?   + How could you improve your design?   + What are the best features of your design? * submit completed workbook. * present video to class.   Celebration and Award ceremony | Moviemaker or other video editing software  Teacher Guide   * Section 7   Data Projector |  |

All outcomes referred to in this unit come from [Technology Mandatory Years 7-8 Syllabus 2017](http://educationstandards.nsw.edu.au/wps/portal/nesa/k-10/learning-areas/technologies/technology-mandatory-7-8-new-syllabus)  
© NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2017

© [Scorpio Technology](http://www.scorpiotechnology.com.au/) 2018. This teaching unit has been adapted to comply with the Department’s accessibility and style guidelines with the kind permission of [Scorpio Technology](https://www.scorpiotechnology.com.au/).

(HPRM MAIL18/282230).

This resource was developed by:

* Bernie Livermore, Birrong Boys High School

The following people and organisations contributed to the consultation and development of the materials.

* Scorpio Technology Vic. Pty. Ltd
* Peter Davis, Normanhurst Boys High School
* Marlene Wakefield, East Hills Girls Technology high School
* Dan Rytmeister, Learning and teaching Directorate