Aeronaut – 9 iSTEM – Stage 5 program

## Summary

## Aerodynamics is the study of air flow around solid objects in reference to the design and function of many forms of transportation. This unit introduces students to the science, technology, engineering and mathematical principles of aeronautical design. Using inquiry and project based learning, students apply an iterative design process to develop, test and evaluate engineered solutions for rockets and planes with opportunities to transfer knowledge and skills to automobile designs.

## As students explore Aerodynamics (Stage 5 iSTEM Elective Module 5), they will acquire and demonstrate essential STEM fundamental skills and knowledge (Stage 5 iSTEM Core Module 1) that will underpin further learning and project work in years 9 & 10.

## Duration

11 weeks

Outcomes

**5.1.1 develops ideas and explores solutions to STEM based problems
5.1.2 demonstrated initiative, entrepreneurship, resilience and cognitive flexibility through the completion of practical STEM based activities 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 a knowledge and understanding of STEM principles and processes
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
5.7.1 demonstrates an appreciation of the value of STEM in the world in which they live
5.8.1 understands the importance of working collaboratively, cooperatively and respectfully in the completion of STEM activities**

## Core & Elective Module Outcomes

**C1.1** STEM investigations (systematic observation, measurement, experiment formulation, testing and modification of hypotheses
**C1.2** the use of STEM in developing solutions to problems (hardware & software)
**C2.1** STEM principles (strength of materials, material properties, fluid mechanics, electricity & magnetism and thermodynamics)
**E5.1** research and exploration (interpreting and analysing data, quantitative and qualitative research, surveys, interviews, observation & testing and experimenting)
**E5.2** technologies related to aerodynamics (wind tunnels, smoke tunnels, computational fluid dynamics (CFD)
**E5.3** aerodynamics principles (dynamic, static friction, drag ratios, lift, drag, weight, thrust, Finite Element Analysis (FEA) & flight)
**E5.4** aerodynamics forces (lift, drag, weight, thrust, simple vectors & efficiency)
**E5.5** aerodynamics design solutions

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## Unit overview

Students explore the mathematical, scientific, technological and engineering principles of Aerodynamics and apply STEM Fundamentals in the design of practical projects using an engineering design process. Students develop an understanding of STEM connections of Aerodynamics within the world they live, including related skills, industries and careers.

Students investigate past, current and emerging technologies and design elements through the development of prototypes to simulate the impacts of aerodynamic principles on aesthetics, efficiency and function of engineered rocket, aeroplane and automobile solutions. Students develop inquiry and project based learning skills appropriate to STEM practice through both individual and collaborative tasks using relevant software and hardware to produce engineered solutions.

Students design, produce, evaluate and communicate solutions to aerodynamic problems related to lift, drag, weight and thrust to meet detailed specifications.

## Resources overview

The resources and links listed below are referenced within the program but is not an exhaustive list of resources available. Teachers can add to these resources as needed.

### Physical resources

* Nuts & Bolts Bottle Rocket Folio.
* Skylap teaching resource pack.
* Rocketman Bottle Rocket Launcher & Power Anchor Testing Device.
* Splat 3D tools.

#### Websites

* [Careers with STEM](https://careerswithstem.com.au/)
* [How to build a water rocket](https://www.sciencelearn.org.nz/resources/406-water-bottle-rockets)
* [Aerodynamics in Racing](https://www.f1technical.net/articles/10)
* [What are wind tunnels (NASA)](https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-are-wind-tunnels-58.html)
* [Aeronautical Velocity Challenge](https://www.facebook.com/AeronauticalVelocityChallenge/)
* [Excite and Educate (Bottle Rocket Equipment)](https://www.facebook.com/exciteandeducate?redirect=false)
* [Designability (Skylap planes and cars)](https://designability.com.au/classroom_cat/skylap/)

#### Videos

* [Principles of flight](https://youtu.be/5O-j0w-h7v0)
* [Coanda effect](https://youtu.be/NvzXKZNJ7ZU)
* [Bernoulli’s principle](https://youtu.be/HmDYbnGnhpA)
* [Newton’s third law of motion](https://youtu.be/TVAxASr0iUY)
* [Paines flyish fish rocket](https://www.facebook.com/AeronauticalVelocityChallenge/videos/1758151097586135/)

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| **Content** | **Teaching and learning** | **Evidence of learning**  | **Adjustments and registration** |
| **Week 1*** Develop a shared definition of STEM, identify STEM skills with reference to the iSTEM process (Engineering Design Process) and explore why STEM careers are important in local, national and global contexts.
 | **Teacher*** Outline classroom expectations and lesson organisation.
* Demonstrate online learning platform (for example: how to find, login and use Google Classroom).
* Introduce the unit by discussing the use of STEM skills and equipment in society and how technological innovations impact on career opportunities through generations. The use of a comparison or example related to aerodynamics (skill or technology changes from 1850s railway innovation to bullet trains) will help set the tone for the unit but encourage students to share ideas of other industries such as Cyber Security or the impacts of rapid prototyping technologies across multiple industries.
* Draw attention to essential skills or soft skills such as Collaboration, Communication, Creative Problem Solving and Critical Thinking skills as well as Resilience / Grit as desirable foundations and employability skills.

**Students*** Complete brainstorming exercise in student booklet or online tools such as Google Draw, Lucid Charts, MindMup or Coggle (collaborative mindmapping).

**As a Class*** Class discussion – classifying STEM skills; student volunteer to write on the board or record ideas in a shareable document with teacher facilitating discussion.
* Class debate - Mistakes are the magic of innovation.

**Teacher*** Gives verbal feedback and elaborates on content raised by students. Teacher suggests possible classifications and connections of STEM skills between industries (for example applied mathematics, problem solving and iterative design across a wide range of Engineering, Science and Technology disciplines).
* Leads a class reading of a [Careers with STEM](https://careerswithstem.com.au/) career profile to scaffold identification of STEM skills.
* Outlines the stages of the iSTEM process and emphasises the importance of iterative design, inclusivity and resilience in problem solving.

**Students*** Individually or in pairs read a different career profile article from the Careers in STEM magazine or website. Think, Pair, Share with students adding new skills or ideas to their mindmaps. This activity works best with several pre-selected articles with students randomly receiving articles.
* Identify examples, tools or strategies for each stage of the iSTEM process.

**Optional extension*** Students to research a chosen career in aerodynamics with a focus on identifying skill sets and qualifications.
* Studentsevaluate the effects of engineering, both positive and negative on society by researching engineering disasters.
 | * Students responses demonstrate an understanding of:
* the use of STEM equipment in today’s society.
* impacts of innovation on career opportunities
* the classification of STEM skills.
* Students justification of the classification of STEM skills demonstrates an understanding of transferable and desirable employability skills in future focused careers.
* Students exploration and articulation of the perception of mistakes as both positive and negative outcomes, develops a foundation for embracing interactive design, resilience and a solution focused mindset.
* Student familiarisation with the iSTEM process will establish portfolio skills and a scaffold for future assessment.
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| **Week 2** * Define aerodynamics and investigate how aerodynamic forces (lift, drag, thrust) and scientific principles (Bernoulli's principle, the Coanda effect, and Newton's third law of motion), affect form and function of a variety of engineering solutions:
	+ rockets
	+ planes
	+ cars
	+ trains
	+ motorcycles.
 | **Teacher*** Define aerodynamics.
* Outline the four basic forces within aerodynamics;
* lift - keeps an aircraft airbourne
* thrust - momentum to propel an aircraft forward.
* drag - resistance to hold an aircraft back.
* weight - force of gravity pulling an aircraft down.

**Class*** Class discussion - Round Robin Brainstorm Technique (split the class into 5 groups) with each group sharing their ideas on a given question with the class; record answers on the board or in a share document (this will be revised after watching the video).
* How are the designs of rockets and planes affected by aerodynamics?
* How does wing design impact and create lift?
* Which components of an aircraft would be responsible for creating thrust?
* How does rocket fin design affect drag?
* Why do we need to consider weight in the design of different aircrafts?
* What is the difference between a fluid and a liquid?
* Watch the [Principles of Flight](https://youtu.be/5O-j0w-h7v0) ; discuss the previous answers and adjust as needed in student notes or in the shared document.

**Student*** Sketch thumbnail diagrams explaining how lift, thrust, drag & weight are applied in rocket designs.
* Experiment with the forces of aerodynamics using a simulation to complete the [Rocket Launch Challenge](https://www.sciencelearn.org.nz/resources/407-launch-simulator-challenge).
* Students choose one of the scientific principles listed, watch the video and write a summary of how the aerodynamic principle affects lift:
* [Coanda Effect](https://youtu.be/NvzXKZNJ7ZU)
* [Bernoulli’s Principle](https://youtu.be/HmDYbnGnhpA)
* [Newton’s thrid law of motion](https://youtu.be/TVAxASr0iUY)

**Optional adjustment*** Teacher demonstrates scientific principles of aerodynamics with a simulated experiment:
* Coanda Effect - hair dryer and ping pong ball and basketball ([video example](https://youtu.be/NvzXKZNJ7ZU))
* Bernoulli’s Principle - hair dryer and ping pong ball ([video example](https://youtu.be/KFE98nje_L0))
* Newton’s third law of motion - tennis ball ([video example](https://youtu.be/MUgFT1hRTE4)).
 | * Students are able to outline the four principles of flight.
* Students responses demonstrate an understanding of at least one of the principles of aerodynamics (Coanda effect, Bernoulli’s Principles & Newton’s third law of motion).
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| **Week 3*** Explore Aeronautical rocket fin design concepts.
 | **Teacher*** Introduce the Bottle Rocket Folio (iSTEM Booklet) and outline the requirements of the Bottle Rocket Challenge.
* Outline the materials needed or provide an example of a pre-constructed bottle rocket.
* Review the aerodynamic force of drag.

**As a class*** Watch an example test flight of a bottle rocket for the Aeronautical Velocity Challenge - Paines Flyish Fish Rocket (Facebook Video).
* Using the ‘Define the Problem’ template in the Bottle Rocket Folio, brainstorm and record ideas on how to engineer a rocket for the following areas:
* aerodynamics
* operational Requirements
* low Weight
* stable Flight.

**Student - Pairs*** Research requirements of the [Australian Aeronautical Velocity Challeng](https://www.facebook.com/AeronauticalVelocityChallenge/?__tn__=kCH-R&eid=ARB44sQjtH7Z4uw0tZEVvyXiOJS4lpwD80lQq-VxZxnRIFVcBy0YrWqthofu8385CWrE8DeCC0HOYebn&hc_ref=ARSCzA7oiBB3uScZtNLzol4yfaj-083Kvp0dg_bD3KkXFAL8ZQgVyvEsu5eiwlfwX78&fref=nf&__xts__%5B0%5D=68.ARB2kyxUX2Td_IYBhFrj9dKkI1IFUYDBh0zaUNzJZ_aWwU9A7N3-H0kI7-IX7RSc8OsdKHztHdCnz3zQVrNBm3VVGs6vA_ZlUcHDVv6oiWVk6Z8Wq_xK5LxSms5cOzJZKOJ6mDxOC-1ItWp52T8xBO8x45rCkkIfTxTExpgit6op1dfwjZN5U9isZSssmVDxAxXRKPATa32108AO1-dHr0fomBVXPa75gRoqlABdFq7vjkIj5nP0IhltEsRdS3e-qJAf_a55h8pWGlBcCVp4OgJTgOSYnCpbSEnVbLtlo8TxeR4YoVtxDlsF9OL02-Pj4UKU2wQ1VzLbLFvpmd6OKfMmz8fffaWoHkjkIy7DEaj4OKOkYsXrQQci76wWKe57RyLpBzesrQewcGavD_zcCA_A6AOCYJUp5Dzddt_CEyZiFI2cgwOOY5PYxyh6rAjwD9s_u4A0F0c1-bc34xU-YHCUCp9p4D77P1Yd130ui_hFjE72ENAc67_0bCrKbYZQKg)e (Bottle rockets).
* Plan a timeline for the development of a bottle rocket by completing the ‘Identify Constraints’ pages of the Bottle Rocket Folio
* construct a GANTT chart
* identify materials
* identify project criteria
* identify tools and equipment.
* Research rocket fin designs and complete the ‘Brainstorm’ pages of the Bottle Rocket Folio:
* *Activity:* draw thumbnail sketches of five different fin shapes
* *Activity:* draw four bottle rockets (two stage rocket, engine gimbal, canards and retro rockets)
* *Activity:* calculate the surface area of fin shapes (triangle, quadrant, rhombus & trapezium)
* *Activity:* Design a fin outline onto bottle shapes with a 2500mmsq surface area.

**Optional adjustment*** Teacher to give students images of example fin designs and discuss the impacts of fin design on drag.

**Optional extension*** Students to experiment with water rocket [simulation software](http://www.seeds2lrn.com/rocketSoftware.html), manipulate variables and analyse statistical data.
 | * Students demonstrate knowledge of the scientific method through exposure to a range of experiments related to aerodynamics.
* Students work collaboratively to develop processes to solve set problems related to aerodynamics (i.e. Aeronautical Velocity Challenge).
* Students apply the iSTEM process to develop a rocket prototype.
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| **Week 4*** Explore the concepts of stable flight (Centre of Pressure & Centre of Mass).
* Design a bottle rocket prototype.
 | **As a Class*** Watch the Bottle Rocket Folio Videos 1 – 2.
* Watch and follow along with the Splat 3D Water Rocket tutorial.

**Students - Pairs*** + Brainstorm activities continued:
		- *Activity:* Construct a simple paper prototype and conduct stability tests to experiment with Centre of Pressure (CP) & Centre of Mass (CM)
		- *Activity:* Sketch and explain spin stabilisation
		- *Activity:* Brainstorm two ideas to guide a rocket during a sideways lift-off.
* Each group member draws and labels an isometric view of a potential rocket design by completing the ‘Design’ pages of the Bottle Rocket Folio.
* Evaluate each design in the group and choose the best design to use for the prototype (Complete the Prototype page of the Bottle Rocket Folio).
* *Activity:* Research and describe two processes for rapid prototyping.

**Optional Extension*** Research which plastic polymer is used in the bottles for student rocket prototypes.
 | * Students responses demonstrate an understanding of how the distance between the Centre of Mass and Centre of Pressure affects rocket stability during flight.
* Students apply an iterative design process in the creation and refinement of prototypes.
* Students labelled drawing demonstrate their intended design and how it links to aerodynamic forces and principles.
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| **Weeks 5 - 7*** Construct a rocket prototype.
* Apply aerodynamic rocket knowledge to aeroplanes.
* Describe characteristics of past, current and emerging aeroplane designs.
* Test, evaluate and refine bottle rocket designs.
* Generate and develop design ideas using drawing techniques.
* Use a variety of techniques to communicate and present the development of design ideas.
 | **Teacher*** Set two dates (initial test & refinement test) for rocket testing (outside or in the school gym).
* Demonstrates the Rocketman bottle rocket launch system and facilitate rocket launches (complete risk assessment prior to launch dates).
* Outline safety guidelines for the Rocketman equipment.
* Introduce Skylap project – refer students to the student workbook.

**Students - Pairs*** Collaboratively build a rocket prototype using appropriate tools and materials.
* Launch rockets and document distance, height & accuracy results on the ‘Evaluate & Test’ pages of the Bottle Rocket Folio.
* Refine rocket designs and conduct second launch test; complete the ‘Iterate” page of the Bottle Rocket Folio.
* Draw a 1:1 scale of the final rocket design (paper or computer aided design); complete the ‘Communicate & Share’ page of the Bottle Rocket Folio.
* Record a 2 minute video explaining the final rocket design and how aerodynamic principles were applied; justify design change choices.

**As a class*** Watch rocket launches and provide verbal or written (PMI Chart) constructive feedback of rocket designs for fellow student groups.
* View a range of historically significant aeroplane designs.
* Discuss the role of innovation and aerodynamics in the changing designs of aeroplanes (past, current & emerging).

**Optional extension*** Students create a multimedia presentation explaining the significant changes to aeroplanes throughout history with at least one emerging design concept with explanations of the effects of aerodynamic principles and forces for each.
 | * Students demonstrate the 4Cs (communication, collaboration, creative problem solving and critical thinking) in the construction of a rocket prototype.
* Students responses demonstrate an understanding of the design features of historically significant aeroplane designs.
* Students labelled drawing demonstrate design modifications and an appreciation of the iterative design process.
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| **Week 8 - 11*** Explain and compare aerodynamic principles of rockets, planes and cars (extension).
* Investigate wind tunnel technology.
* Select and safely use equipment to construct a Skylap Planes.
* Plan and document a procedure (sequence) for the construction of a Skylap plane.
* Test and evaluate the designing and producing of a textile item using a variety of techniques including self-evaluation and peer evaluation.
* Use feedback from evaluation to modify project work and ensure a quality result.
 | **Teacher*** Demonstrate and outline safety guidelines for the Skylap Power Anchor equipment.
* Demonstrate constructions techniques for balsa wood planes and outline safety guidelines for equipment use.

**As a Class*** Watch the [What are wind tunnels (NASA)](https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-are-wind-tunnels-58.html).
* Discuss the importance of using wind tunnel technology to test and evaluate prototype designs.

**Students*** Work individually or collaboratively to produce and evaluate a Skylap plane with supporting documentation by completing the student workbook.
* Demonstrate safe use of equipment.

**Optional Extension*** Experiment with the design of balsa wood cars for the the Power Anchor equipment; highlighting the applications of [aerodynamics for automobiles](https://www.f1technical.net/articles/10).

**Optional adjustment*** Teacher provides partially or pre-constructed planes or cars for testing with Power Anchor equipment with class discussion of aerodynamics for automobiles.
 | * Students are able to formulate a plan of action that accounts for the time they have available.
* Students are able to explain the correct and safe use of Power Anchor equipment.
* Students are observed during practical activities using Power Anchor and construction tools equipment.
* Students demonstrate an understanding of the manufacturing procedure by creating a sequence of construction.
* Students select the correct tools and equipment for the production of their Skylap plane.
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## 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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