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| **Flying by numbers with the lift equation** |
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| Rearranging and using the lift equation |
| **Subjects:** Maths, Engineering**Approx. time:** 50 - 60 minutes |  | **Key words / Topics*** Area
* Density
* Equation
* Graph
* Lift
* Mass
* Table
* Velocity
* Wing
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| **Suggested Learning Outcomes**  |  |  |
| * To be able to manipulate the subject of an formula.
* To be able to use a formula.
* To be able to interpret data in tables and graphs.
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| **Introduction** |  |  |
| This is one of a set of resources produced in conjunction with the engineering company Arconic. The resources are designed to support teaching of key engineering concepts at both key stage 3 and key stage 4, including the new GCSE in Engineering. This resource focusses on the application of maths in engineering.This lift equation is used by aerospace designers to determine the necessary characteristics of an aircraft so that it can fly. |
| **Purpose of this activity**In this activity, learners will apply simple mathematical concepts to carry out a real-world design activity. This will support their understanding of:* manipulating the subject of equations;
* using equations;
* interpreting data presented in tables and graphs.

This could be used as a one-off main lesson activity, as an introductory lesson to a wider unit of work focussing on aerodynamics or as part of a scheme on aircraft design using all of the resources developed in association with Arconic. |
| **Activity**  |  | **Teacher notes** |
| **1. Overview: what is lift? (5 mins)**Teacher to outline what is lift and discuss its importance. Presentation of the lift equation and explanation of the values it uses.**2. Changing the subject of a formula (20-25 mins)**Brief recap, if necessary, of how to change the subject of an equation. Learners rearrange the lift formula, firstly to make wing area the subject, then velocity. Students complete the relevant questions on page 1 of the worksheet.**3. Interpreting data (25-30 mins)**Brief recap by demonstration, if necessary, of reading data from tables and graphs using the handout. Learners complete the questions 5 and 6 on the worksheet. |  | The key aim of this activity is for students to apply their mathematical skills in an unfamiliar context. The lift equation is L = d x v2 x s x CL / 2. This is used by aircraft designers and helps pilots to know what characteristics need changing to maintain effective flight. After activities 2 and 3, learners could mark each other’s responses and provide peer feedback on errors. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| The first attempt at changing the subject could be carried out as a demonstration or class activity.Learners could be provided with worked examples of the calculations, using different values. |  | Learners could use the handout to calculate the lift generated by the actual aircraft listed under various operating conditions. For a selected aircraft, learners could carry out calculations to determine the angle of attack needed to maintain steady flight for these aircraft at a given altitude. They could also plot the angle of attack needed to maintain steady flight at different altitudes.Learners could create their own aircraft designs for a given set of operating conditions (e.g. specified load, top speed and maximum altitude), calculating the wing areas needed and incorporating these into their designs.  |
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Projector/Whiteboard
* Handouts and worksheets
 |  | icon-ppt Flying by numbers presentationicon-pdf Flying by numbers handouticon-pdf Flying by numbers worksheet |
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| **Additional websites** |  |  |
| The following websites can be used for additional background information or to aid with the activity: * **NASA – Beginner’s guide to aerodynamics:** Resources for teaching and studying the theory of aerodynamics. <https://www.grc.nasa.gov/www/k-12/airplane/bga.html>
* **NASA – lift equation:** Explanation of the lift equation, how it is used and additional eexercises. <https://www.grc.nasa.gov/www/K-12/airplane/lifteq.html>, <https://wright.nasa.gov/airplane/lifteq.html> and https://www.grc.nasa.gov/WWW/K-12/WindTunnel/Activities/lift\_formula.html.
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| **Related activities (to build a full lesson)** |  |  |
| **Starters*** Identify and describe examples everyday applications of aerodynamics.
* ACTIVITY: What is aerodynamics?

**Main*** ACTIVITY: Flying by numbers with the lift equation
 | **Plenary*** Discuss the differences in aircraft and aerofoil design and how these affect how an aircraft flies.
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| **The Engineering Context** film |
| Aerodynamics is required learning as part of the GCSE Engineering 9-1 course. The knowledge gained can also be used when designing products that have an aerodynamics element to them, such as racing vehicles or different types of aircraft. |

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| **Curriculum links**  |
| **England: National Curriculum**KS3 Mathematics* 1b, 1d, 3a, 3c, 4d, 4g, 4h, 4l, 5b, 5c, 5e, 6a, 6i, 6j, 9b
 | **Scotland: Curriculum for Excellence**Technologies* MTH 3-06a, MNU 3-04a, MNU 3-07a, MNU 3-10a, MNU 3-11a,

MNU 4-03a, MTH 4-06a, MTH 4-06b, MTH 4-07b, MNU 4-11a, MTH 4-12a, MNU 4-20a |
| **Northern Ireland: Curriculum**KS3 Mathematics* Developing pupils’ knowledge, understanding and skills / the application of mathematical skills to real life and work situations; knowledge and understanding of number, handling data
* Objective 3: Explore how the skills developed through mathematics will be useful to a range of careers.
 | **Wales: National Curriculum**KS3 Mathematics* Developing numerical reasoning / identify processes and connections / use a scientific calculator to carry out calculations effectively and efficiently using the available range of function keys
* Developing numerical reasoning / represent and communicate / interpret graphs that describe real-life situations
* Using number skills / use number facts and relationships
* Use measuring skills / length, weight / mass, capacity
* Using algebra skills / expressions and formulae
* Using algebra skills / equations and inequalities
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| **GCSE Mathematics**AQA * N2, N6, N7, N9, N13
* A2, A3, A5, A14
* R1, R11
* G14
* S2

Pearson Edexcel Level 1 / Level 2* N2, N6, N7, N9, N13
* A2, A3, A5, A14
* R1, R11
* G14
* S2

OCR* 1.04a, 2.02a, 3.01a, 3.01b, 3.02a, 3.02b, 6.01a, 6.02b, 6.02c, 7.04a, 10.01a, 10.01b, 12.02a

WJEC Eduqas GCSE (9-1) in MATHEMATICS* FN2, FN6, FN7, FN9, FN13
* FA2, FA3, FA5, FA13
* FR1, FR12
* FG12
* FS3

(Also applicable to higher level, where the F is replaced by a H) | **GCSE Engineering**AQA Engineering* 3.4.3
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| **Assessment opportunities** |
| Review of the completed worksheets. |
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| **Personal, learning & thinking skills (PLTS)** |
| * Self-manager
* Effective participator
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