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| **Solar powered engine** |
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| Making a model of an electric aircraft engine and calculating for how long this could power an aircraft |
| **Subject(s):** Design and Technology, Engineering, Mathematics**Approx time:** 50-70 minutes |  | **Key words / Topics:** * components
* crocodile clips
* future flight
* motors
* power supplies
* rechargeable batteries
* solar energy
* switches
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| **Stay safe** Whether you are a scientist researching a new medicine or an engineer solving climate change, safety always comes first. An adult must always be around and supervising when doing this activity. You are responsible for:• ensuring that any equipment used for this activity is in good working condition• behaving sensibly and following any safety instructions so as not to hurt or injure yourself or others Please note that in the absence of any negligence or other breach of duty by us, this activity is carried out at your own risk. It is important to take extra care at the stages marked with this symbol: ⚠ |
| **Suggested Learning Outcomes**  |  |  |
| * To be able to make and test a model of a solar charged electric aircraft engine
* To be able to calculate for how long this could power an aircraft
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| **Introduction** |  |  |
| This is one of a series of resources designed to allow learners to use the theme of the future of flight to develop their knowledge and skills in Design & Technology, Engineering and Mathematics. This resource focusses on making and testing a model of an electric aircraft engine and calculating how long it can run for.Jet engines used on aircraft produce a lot of carbon emissions. Can you make an electric aircraft engine that only runs off solar charged batteries?  |
| **Purpose of this activity**In this activity learners will make use of the theme of the future of flight to make a model of an electric aircraft engine that uses solar-powered rechargeable batteries and a motor. They will then test their circuit to see if it works and calculate how long it can run for before it needs to be recharged.This activity could be used as a main lesson activity to teach about assembling models of circuits and the use of renewable energy. It could also be used as part of a wider scheme of learning to support focussed practical skills within Design and Technology and Engineering, or about engineering career opportunities within the aviation sector. |
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| **Activity** |  | **Teacher notes** |
| **Introduction, brief and safety (10 minutes)**Teacher to explain the task to learners, introduce the brief using the presentation.Teacher to hand out the tools, equipment and components required. **Making the electric engine model (20-30 minutes)**Teacher to demonstrate steps shown below and on the presentation. Learners to then follow these steps to produce their own electric engine circuit model.* Step 1 – Fit the two rechargeable AA batteries into the solar charger. Place the charger outside in direct sunlight. Wait for the batteries to become fully charged. ⚠
* Step 2 - Connect one end of a black crocodile clip to the negative connector on the battery holder. Connect one end of a red crocodile clip to the positive connector. ⚠
* Step 3 - Connect the other end of the red crocodile clip connected to the battery to an outside pin of the switch. Connect one end of a different red crocodile clip to the middle pin of the switch. ⚠
* Step 4 - Connect the other end of the red crocodile clip connected to the middle of the switch to the red motor wire. Connect the other end of the black crocodile clip connected to the battery holder to the black motor wire. ⚠

**Testing the circuit (10 minutes)**Learners to place the charged batteries into the battery holder and turn on the switch to test the circuit. The engine motor should turn, so the engine is ‘on’.**Calculations (10-20 minutes)**Learners to calculate the number of hours that the motor could run for on a single charge. Teacher to discuss the implications of this with learners. |  | **Resources**A solar charger such as this could be used: <https://www.amazon.co.uk/gp/product/B073W8VLTN> The motor must be appropriate to the power supply voltages used. For example, a low inertia solar motor, such as the below, would work with two AA batteries. <https://kitronik.co.uk/products/2546-low-inertia-solar-motor-1000-rpm?gclid=CjwKCAjw3K2XBhAzEiwAmmgrAv7Bv_lKz-z9DWuAiOtcbbDhqhaFqkvDc4D5erxWcYOzAMZMbZhHORoC53MQAvD_BwE> **Solar battery charging**Safety note – never connect a solar cell directly to a battery unless there is also an overcharge circuit present. Without this current will still be supplied even when the battery is fully charged and could cause excessive heat, fire or even an explosion. For this reason it is strongly recommended to use a commercially available solar battery charger with built-in overcharge protection and to charge the batteries separately before inserting them into the main circuit. Rechargeable batteries appropriate to the type of charger must be used. The time taken to charge will vary depending on the amount of sunlight received, but typically this could be anything from a few hours to a full day. This step could therefore be done the day before the rest of the activity to give sufficient charging time, or the batteries could be pre-charged by the teacher. It is important however that learners understand how solar charging works and therefore this should still be shown to them.**Making the circuit model**Colour coding of the crocodile clips helps with the understanding of the completed circuit and any necessary fault finding. Ensure the battery connectors are the right way around and are not touching each other. Ensure the two switch connectors are not touching each other, as this will mean the switch is permanently on. Any outside pin can be used for the red clip. A propeller can be fitted to the motor for added authenticity!**Testing**When the batteries are connected and the switch turned on, the motor should create rotary movement. If the circuit does not work check the connections are secure and there are no short circuits.**Calculations**The exact numbers used can be changed depending on the exact power supplies, motors etc. used. This information can be found on the relevant datasheets at the point of purchase. The example in the teacher presentation is based on 2 x 1.5 V AA batteries and a motor current draw of 0.1 A. |
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| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * Pre-charge the batteries prior to making the circuit model.
* Show an exemplar or print a wiring diagram to aid with circuit assembly.
 |  | * Investigate the sizes of electric battery engines that are available – how long would these work with their batteries? How far could the aircraft fly?
* Using the information in the BBC webpage <https://www.bbc.com/future/article/20200617-the-largest-electric-plane-ever-to-fly>, work out where current electric aircraft could fly to on a single charge. How would using these aircraft affect air travel?
* Construct a gearing system so that the velocity and torque of the engine can be adjusted.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Solar AA battery charger
* 2 x rechargeable AA batteries
* AA batteries connector/holder
* Red and black crocodile clips
* Slide or toggle switch
* Electric solar motor
* Atlas (for extension activity determining potential journey destinations)
 |  |  Presentation – Solar powered engine |
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| **Additional websites** |
| * **NASA – Why build an electric engine?:** Explanation of the reasons why electric aircraft should be built. <https://www.nasa.gov/specials/X57/electric-airplane.html>
* **The largest electric aircraft ever to fly (so far)** https://www.bbc.com/future/article/20200617-the-largest-electric-plane-ever-to-fly
* **Wikipedia – Electric aircraft:** Explanation of how and why electric powered aircraft are being developed and the technologies used. <https://en.wikipedia.org/wiki/Electric_aircraft>
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Discuss how electric aircraft engines could help the environment.
* Research components to be used and discuss their function in the circuit.
* Draw a schematic and wiring diagram for the circuit.
 | **Plenary*** Evaluate the results of testing the circuit.
* Self/peer asses the calculations performed.
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| **The Engineering Context** film |
| * The future of flight is a great context to explore the opportunities that working in the aeronautical engineering industry presents! For example, designing, making and maintaining aircraft and all their different parts.
* Electrical and electronic engineers need to have basic skills in circuit modelling and assembly, including wiring and testing electrical circuits.
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| **Curriculum links** |
| **England: National Curriculum**Design & Technology * KS3 2b, 3d, 4c, 4d

**GCSE D&T**AQA D&T* 3.1.1, 3.1.2, 3.1.4, 3.2.3, 3.2.5, 3.3.2, 3.3.5, 3.3.6

Edexcel D&T* 1.1.3, 1.1.7, 1.2.2, 1.2.4, 1.3, 1.6.2, 5.2.3, 5.2.8,

Eduqas D&T* Core: 1, 2, 3, 5
* Electronic systems: 1, 2

OCR D&T* 2.1a, 2.2a, 3.1a, 4.1a, 6.3a, 6.4
 | **Northern Ireland Curriculum**Technology & Design* KS3 Control – incorporate control systems, such as mechanical,

electronic or computer-based, in products and understand how these can be employed to achieve desired effects |
| **England: GCSE Engineering*** 3.1.3, 3.3.2, 3.4.1, 3.4.2, 3.4.3, 3.5

**Scotland: Curriculum for Excellence**Technologies* TCH 3-07a TCH 3-09a TCH 3-12a
* TCH 4-12a
 | **Wales: National Curriculum** Design and Technology* KS3 Skills: Designing 1, 4, 7, 8
* KS3 Skills: Making 1
* KS3 Systems: 16, 18
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| **Assessment opportunities** |
| * Informal teacher assessment of practical skills through observation of learners.
* Formal teacher assessment of the completed circuit model.
* Formal teacher assessment of calculations produced.
* Self/peer assessment of calculations produced.
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