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| **Make a flood barrier system** | | |
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| Designing and making a circuit to detect an overflow from a river and raise a temporary barrier using Crumble | | |
| **Subject(s):** Design and Technology, Engineering  **Approx time:** 70-110 minutes |  | **Key words / Topics:**   * components * crocodile clips * flooding * input, process, output * microcontrollers * moisture sensors * motors * programmable components * systems |
| **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 design and make an electronic control system for a flood barrier * To understand how block diagrams are used to represent systems * To be able to use programmable components to solve a real engineering problem | | |
| **Introduction** |  |  |
| This is one of a series of resources produced in association with Fairfield Control Systems that are designed to allow learners to use the theme of waterways to develop their knowledge and skills in Design & Technology and Engineering. This resource focusses on designing and making a programmable electronic system to control a flood barrier.  Because of climate change, many parts of the world are now at risk of flooding. Can you design and make a system that closes a barrier when the water level in a river gets too high? | | |
| **Purpose of this activity**  In this activity learners will make use of the theme of waterways to design and make an electronic circuit for an automatic flood barrier. They will produce a block diagram of their system design. They will then assemble their system and use Crumble software to program it to perform the required functions.  This activity could be used as a main lesson activity to teach about embedding programmable components in systems and assembling and testing programmable systems. It could also be used as part of a wider scheme of learning focussing on social issues and the importance of the waterways in the United Kingdom. | | |
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| **Activity** |  | | **Teacher notes** |
| **Introduction, brief and safety (10-20 minutes)**  Teacher to explain the task to learners and introduce the design brief on slide 3 of the presentation.  Teacher to hand out the tools, equipment and components required.  **Designing the system (20-30 minutes)**  Learners to produce a block diagram showing their design idea for a suitable system. Teacher to explain that they are going to use a programmable microcontroller in their system. Teacher to show the example on slide 5 of the presentation to help where necessary.  **Making and programming the system (40-60 minutes)**  Teacher to demonstrate steps shown below and on the presentation as an example of how a system could be assembled and programmed to satisfy the brief using the Crumble microcontroller system. Learners to then make and program their own programmable electronic flood barrier system.   * Step 1 – Fit three AA batteries into the battery pack. Attach one end of a red crocodile clip to the red lead on the battery pack and the other to the + power port on the Crumble. Attach one end of a black crocodile clip to the black lead on the battery pack and the other to the - power port on the Crumble. ⚠ * Step 2 - Connect one end of a red crocodile clip to the + leg of the motor and the other to the + motor 1 output port on the Crumble. Connect one end of a black crocodile clip to the - leg of the motor and the other to the - motor 1 output port on the Crumble. * Step 3 - Cut out a piece of card measuring approximately 50 mm x 15 mm. Cover it in sticky tape so it is waterproof. Cut out two strips of copper tape 50 mm long. Stick these onto the card piece with a small gap between them. This will now act as moisture sensor. ⚠ * Step 4 - Connect one end of a red crocodile clip to one of the copper strips and the other end to the + port on the right hand side of the Crumble. Connect one end of a black crocodile clip to the other copper strip and the other end to port C on the right hand side of the Crumble. * Step 5 - Use the Crumble programming software to write the program for the flood barrier. The example can act as a starting point. * Step 6 - Connect the download cable to the crumble board and the computer USB port. Turn the battery pack ‘on’. Press the green play button on the software to download the program to the Crumble microcontroller. * Testing - Place the sensor into water to test if the circuit works. |  | | **Systems block diagram**  Slide 4 of the presentation could be printed as a template for learners or they could draw their design idea on a separate piece of paper or in their exercise books. Higher ability learners could draw their idea without the template or add additional blocks to their design to make it more complex. For example, a warning buzzer or flashing light when the barrier is being lifted.  Learners could discuss the advantages and disadvantages of using a microcontroller instead of discrete components for the system.  **Crumble system**  Presentation slides 6-15 present an example solution based on the use of the Crumble programmable microcontroller system by Redfern Electronics. https://redfernelectronics.co.uk/crumble/. Kits can be purchased from the website containing the main parts and components required. Additional resources for making a DIY moisture sensor are also shown.  These slides could be adapted by the teacher for other programmable systems as used in their own school.  **Assembling the circuit**  During step 1 care must be taken to put the batteries the correct way around in the pack (correct polarity). Do NOT ask learners to turn the power pack on at this point. If using a battery pack without an on/off switch do this step just before programming.  Step 3 (making a moisture sensor) is optional as the system can operate by simply placing the ends of the appropriate crocodile clips into the water. It does however give an opportunity for learners to demonstrate additional practical skills and knowledge as to how a moisture sensor works. When the sensor is placed in water current will conduct between the two pieces of copper tape, this ‘making’ the circuit and acting as a switch/sensor input to the Crumble microcontroller.  Take care when using scissors to cut out card and copper tape and be careful of any sharp edges.  Further information about making a moisture sensor can be found here: <https://redfernelectronics.co.uk/category/crumble-projects/>  **Programming the circuit**  An example program is shown on slide 12 of the presentation to get learners started. This program will need to be reset each time it is used (this can be achieved by turning the battery pack off and on again) due to it being set to run through the code just once. This prevents the sensor from continuously triggering movement of the motor after the initial time period has elapsed (i.e. after the barrier has been moved into place). Most learners should try to improve upon or modify this program (such as by adding a way for it to move the barrier back once the water levels have dropped etc.) but weaker learners could download it straight onto their circuit.  Teacher should demonstrate use of the software if learners have not used it before.  **Testing**  The video on slide 15 shows the circuit being tested. Always take care when using electricity near water. No other parts of the circuit should be placed in the water.  If a sensor has not been made, then the circuit can be tested by placing the unused ends of the port C crocodile clips directly into the water. |
| **Differentiation** |  | |  |
| **Basic** |  | | **Extension** |
| * Provide a partially completed template for producing the systems block diagram. * Pre-download the example program onto the Crumble microcontroller boards. * Provide a diagram to aid with system assembly. |  | | * Design a mechanical system to convert the rotary motion from the motor to the movement of a barrier. * Update the program to take account of this mechanical movement (e.g. the time needed to move the barrier). * Add light or sound outputs to the system to warn people when the barrier is moving. |
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| **Resources** |  | | **Required files** icon-docicon-pdficon-ppt |
| * Crumble controller board and USB download cable * Three red crocodile clips and three black crocodile clips * Three AA batteries and battery pack * Crumble motor * Bowl of water for testing   To make a moisture sensor:   * Copper tape * Card * Sticky tape * Scissors |  | | Presentation – Make a flood barrier system   * Flood barrier example program * Flood barrier system test video |
| **Additional websites** |  | |  |
| * **Fairfield Control systems website:** [https://www.fairfields.co.uk/](https://emea01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.fairfields.co.uk%2F&data=05%7C01%7C%7C4dc3028e5da442738d9f08dad86492aa%7C84df9e7fe9f640afb435aaaaaaaaaaaa%7C1%7C0%7C638060223713198401%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=HArsg5SYyeH3563Zd3%2ByRwiYrh8tbOAi2tWit%2BsWM5w%3D&reserved=0) , <https://www.fairfields.co.uk/fcs/sectors/waterways/> * **Perry Barr and Witton flood risk management scheme:** <https://www.gov.uk/government/publications/perry-barr-and-witton-flood-risk-management-scheme/perry-barr-and-witton-flood-risk-management-scheme> * **Anderton Boat lift, Cheshire:** <https://canalrivertrust.org.uk/places-to-visit/anderton-boat-lift-visitor-centre> * **Crumble projects, including a moisture sensor:** <https://redfernelectronics.co.uk/category/crumble-projects/> | | | |
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| **Related activities (to build a full lesson)** |  | |  |
| **Starters** (Options)   * Research examples of existing flood barrier systems. * Discuss the advantages and disadvantages of using programmable components in electronic systems. | | **Plenary**   * Evaluate the results of testing the circuit. * Draw a schematic and/or wiring diagram for the circuit. * List improvements that could be made to the finished system. | |
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| **The Engineering Context** film | | | |
| * The waterways (including their protection, maintenance and control) is an excellent context to explore opportunities that working in the engineering industry presents. For example, designing and making control systems that help the waterways to work more effectively. * Electrical, electronic and control engineers need to have knowledge, understanding and skills associated with circuit design and assembly, and the programming of electronic control systems. | | | |

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| **Curriculum links** | |
| **England: National Curriculum**  Design & Technology   * KS3 1b, 1e * KS3 2a, 2b * KS3 3c, 3d * KS3 4c, 4d   **GCSE D&T**  AQA D&T   * 3.1.1, 3.1.4, 3.3.2, 3.3.4, 3.3.5, 3.3.6   Edexcel D&T   * 1.6, 1.7, 1.16.1c, 1.17.1j, 5.2.1c, 5.2.2i, 5.2.3d   Eduqas D&T   * Core: 5, 6 * Electronic systems: 1   OCR D&T   * 1.1, 3.3, 4.2aii, 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**   * 3.3.2, 3.3.3, 3.4.2   **Scotland: Curriculum for Excellence**  Technologies   * TCH 3-01a, TCH 3-13b, TCH 3-14a, TCH 3-15a * TCH 4-09a, TCH 4-12a | **Wales: National Curriculum**  Design and Technology   * KS3 Skills: Designing 1, 2, 3, 4 * KS3 Systems and controls: 16, 17, 18, 20, 21 |

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| **Assessment opportunities** |
| * Informal teacher assessment of practical skills through observation of learners. * Formal teacher assessment of flood barrier system designs and block diagrams. * Formal teacher assessment of the assembled and programmed flood barrier system. * Self/peer assessment of designs and practical outcomes produced. |