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| **Heat Shield** |
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| Evaluating materials for a heat shield to prevent a piece of chocolate from melting |
| **Subject(s):** Design and Technology, Engineering**Approx time:** 50-70 minutes |  | **Key words / Topics:** * future flight
* heat shield
* heat resistance
* insulator
* material properties
* spaceflight
* testing
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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 test different materials to see how well they work as a heat shield
* To be able to record and discuss test results
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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 and Engineering. This resource focusses on selecting the material to make a heat shield to stop a piece of chocolate from melting.The Solar Orbiter has to get very close to the Sun’s surface to observe how it works. It needs a heat shield so its systems do not get too hot and melt. Can you design a heat shield from a suitable material? |
| **Purpose of this activity**In this activity learners will make use of the theme of the future of flight to design, make and test a heat shield to prevent a piece of chocolate from melting. They will test different materials to see which protects the chocolate the best and discuss their results.This activity could be used as a main lesson activity to teach about the properties of different materials and how well they resist heat. It could also be used as part of a wider scheme of learning to support testing and evaluation skills within Design and Technology and Engineering. |
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| **Activity** |  | **Teacher notes** |
| **Introduction and safety (10 minutes)**Teacher to explain the task to learners and introduce the situation and design brief using the presentation.Teacher to make clear the importance to learners of working safely throughout the activity.**Producing the heat shield and testing materials (30-50 minutes)** ⚠Teacher to demonstrate steps shown below and on the presentation. Learners to then follow these steps to test different materials and produce their heat shield.* Step 1 – Place a piece of chocolate in a cup. Place the heat shield material over the top of the cup and secure.
* Step 2 - Heat the shielded chocolate for three minutes. Remove the shield and see how melted the chocolate is. Test three different heat shield materials. ⚠
* Step 3 - Record the results.

**Choosing a heat shield material (10 minutes)** Learners to discuss their results. Use slide 10 in the teacher presentation to assist with this activity. Which material would they use to protect the chocolate?Why? Were they good/bad insulators? Why?How could they change/improve each heat shield?Do learners all agree on the best materials? Did anything surprise them? |  | This activity could be carried out in pairs or small groups.**Resources and equipment**Polystyrene cups were cut down to 4 cm height for the experiments shown in the presentation, to make heating the chocolate easier. Learners could do this using scissors or the teacher could pre-cut them.Learners should pick from a selection of materials. This could include cardboard from a box, metal foil, plastic sheet (e.g. cut from a milk container), heat resistant gauze, wire mesh, fabric, newspaper, and wood. All heat shield materials should be cut to the same size and shape – around the size of the top of the cup. The chocolate should be cut into equal pieces to ensure the same amount is used each time. The same brand of MILK CHOCOLATE should be used for all tests, as different brands have different melting characteristics. White/dark/filled chocolates also all have different melting points that would alter the tests.**Producing the heat shield and testing materials**For the hairdryer, medium heat on a medium setting was used in the examples shown in this presentation. Variations of heat (power) from the hairdryers should be taken into consideration. Risk assessments should take into account electrical safety and potential hazards from heat.The hairdryer should be held over the top of the protected chocolate, around 30 cm away. Tin foil can be moulded around the cup to prevent it moving during heating. Plastic or cardboard may need tape to hold in place while heating.Photographs could be taken of the test results and annotated. Results can be written in the tables shown on the worksheet handout or presented as a PowerPoint or other type of presentation. |
| **Differentiation** |  |  |
| **Basic** |  | **Extension** |
| * The heat shield worksheet handout gives three different tables that can be used to record results, each of increasing levels of difficulty. Weaker learners could complete the first worksheet.
* Pre-cut the polystyrene cups, the chocolate and the heat shield materials to the correct sizes.
 |  | * More able learners could measure the temperatures when heating the chocolate and record these in the table provided in the worksheet handout.
* Design a heat shield that uses a combination of different materials.
* List all the possible applications you can think of for heat shields.
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| **Resources** |  | **Required files** icon-docicon-pdficon-ppt |
| * Polystyrene cups
* Scissors
* Materials for heat shields (e.g. milk bottle plastic, cardboard, metal foil, metal mesh)
* Chocolate pieces
* Hairdryer
* Stopwatch or timer

Additional equipment that could be used:* Thermometer
* Ruler
* Heat mats to place polystyrene cups on
* Oven gloves/cloths/tongs
 |  |  Presentation – Heat shieldicon-pdf Heat shield worksheet handout |
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| **Additional websites** |
| * **NASA – Orion mission heat shield:** Information about the heat shield used in the NASA Orion mission. <https://www.nasa.gov/image-feature/heat-shield-milestone-complete-for-first-orion-mission-with-crew>
* **Cosmos magazine – How do heat shields work:** Article about how heat shields on spacecraft work. <https://cosmosmagazine.com/technology/how-do-heat-shields-on-spacecraft-work/>
* **YouTube - What is a Spacecraft's Heat Shield?:** Video explaining the workings of the heat shield from the famous Apollo missions and how to make a heat shields at home. <https://www.youtube.com/watch?v=qRgRV1iMpEM>
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| **Related activities (to build a full lesson)** |  |  |
| **Starters** (Options) * Research the history of spaceflight and the Solar Orbiter mission.
* Discuss which materials learners think would make good heat shields and why.
 | **Plenary*** Discuss the results of testing – which materials performed best/worst and why?
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| **The Engineering Context** film |
| * Protecting space craft, systems, payloads and people from the effects of heat will be a huge consideration during future spaceflights. Engineers need to understand which materials are the most effective at protecting from possible damage from the Sun’s powerful rays.
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| **Curriculum links**  |
| **England: National Curriculum**Design and technology* KS2 1a, 1b
* KS2 2a, 2b
* KS2 3a, 3b
 | **Northern Ireland Curriculum**The world around us* Movement and Energy: the causes and effect of energy, forces and movement
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| **Scotland: Curriculum for Excellence**Craft, design, engineering and graphics* TCH 1-05a
* TCH 2-09a
* TCH 2-10a
* TCH 2-12a
 | **Wales: National Curriculum** D&T* KS2 Skills: Designing 1, 4, 5, 6, 7
* KS2 Skills: Making 1, 2, 3, 4
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| **Assessment opportunities** |
| * Formal teacher assessment of completed heat shields and testing skills used.
* Peer and/or self-assessment of results of material testing.
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