The Ogden Trust

making physics matter

Phizzi practical

Age 7-11 years

Heat shield testing

Crew Dragon after re-entry
credit:NASA.

Introduction

When spacecraft land on a planet with an atmosphere such as Earth or Mars, they enter the atmosphere at extreme speeds and are slowed down by air resistance caused by air particles hitting them. The friction forces acting on the spacecraft from the air resistance cause the spacecraft to heat up to very high temperatures. To protect the spacecraft from the intense heat, the surface is covered in a heat shield – a protective layer that dissipates the heat. In this practical task, children create their own heat shields to protect their chocolate space capsules.

Scientific explanation

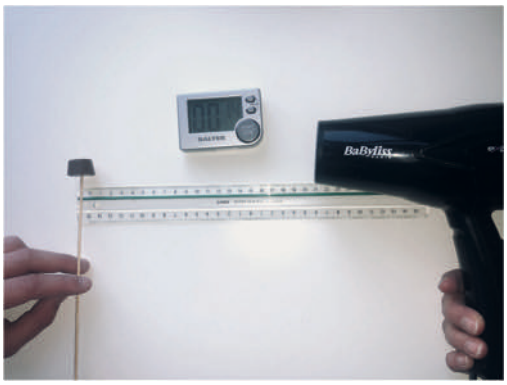
Without proper thermal protection, atmospheric friction can create enough heat to damage or totally destroy a spacecraft on re-entry. Engineers effectively wrap spacecraft in an insulating blanket that could be made from a variety of materials including foams, ceramic tiles or resins. Some insulating materials absorb all the heat and then radiate it back into space, others actually burn and erode and fall from the spacecraft. Heat shields that burn away are also called ablative shields; spacecraft with these are not reusable. The Apollo spacecraft used ablative shields and were only used once, whereas the space shuttle used insulating ceramic tiles that were reusable. It was damage to the heat shield that led to the space shuttle Columbia disaster in 2003.

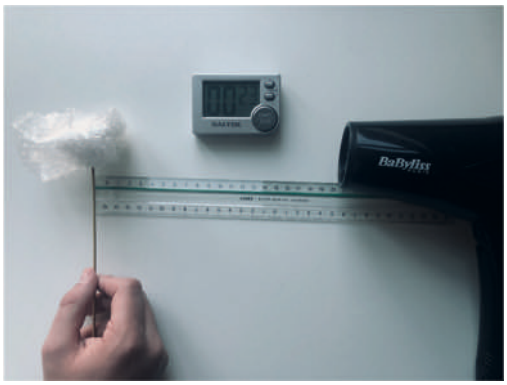
Equipment needed

- Chocolate caramels eg Rolos
- Materials: cotton wool, bubble wrap, foil, tissue paper
- Hairdryer
- Ruler
- Wood skewers
- Stopwatch

Method

1. Begin by seeing how long it takes for the heat from a hair dryer to make the chocolate caramel start to melt.
2. Children can vary the distance between the chocolate caramel and the hairdryer to find the optimum position for their test and they can repeat the test to check their measurements; 20cm worked well with our model.
3. Children should record the results and note the optimum distance and time for melting their chocolate. They will need this information when they test their heat shield.
4. Create a heat shield for the chocolate caramel space capsule by wrapping it in various materials (or combinations of materials).
5. Repeat the test using the hairdryer to heat the protected chocolate caramel spacecraft. The test should be carried at the optimum distance and for the optimum time so the children can compare results.
6. Carefully remove the heat shield to see if the chocolate caramel has melted. If it hasn't, then the material was an effective heat shield; if it has melted, then the heat shield wasn't effective.
7. Repeat the test using different materials and sort them into those that insulate the chocolate caramel spacecraft and those that don't.





Working scientifically

This is a great simple test for discussing control variables – children can identify the factors that they will keep the same so they can be certain that it is the properties of the material that have affected their findings. It is also a good preliminary test that children can use to develop predictions and plan a more structured comparative test to investigate all the insulating materials and find out which one protects the chocolate caramel for the longest time or highest temperature.

Teaching tip

A careful risk assessment needs to be made when using a hair dryer as a heat source in the classroom; teacher supervision and support will be needed. Teachers should note that some materials will melt or smoulder at high temperatures and many will ignite if the temperature is sufficiently high. As with all electrical appliances there is a risk of electric shock, so hair dryers should be inspected before use. It is unlikely, but some materials can release fumes when overheated so this investigation should take place in a ventilated area. Visit CLEAPSS for further advice on the use of heating equipment in the classroom **www.cleapss.org.uk**.