'Lets get Practical'
– How Science Works

OCR
RECOGNISING ACHIEVEMENT

Java Jive

Reference: Gateway Suite Physics Module P1a 'Carry out an experiment to measure the fall in temperature of hot water.'

Hot objects in cooler surroundings will cool down. That cooling sometimes takes a long time. Indeed, our houses are insulated in order to prevent heat loss so that we may enjoy the heat generated by expensive energy for as long as possible!

We often ask students to design methods of minimising heat loss. This challenge originated from the *opposite* requirement – I want my coffee to cool quickly, so that I can drink it!

The experiment therefore addresses a common and familiar problem!

Procedure

Each student is provided with a thermometer; a large china breakfast cup and saucer and metal tea spoon, the cup containing a known volume of water drawn from a kettle whose temperature is noted. This should be at least 90°C.

The combined mass of cup, saucer, spoon and water is also recorded.

The challenge is to reduce the temperature by as much as possible, using nothing other than the cup, saucer, spoon and the students' knowledge of heat transfer.

Some possible options could be:

Stir the coffee with the spoon:

- The whirlpool has a greater surface area than the flat "coffee" so will exchange heat with the air more efficiently
- More hotter "coffee" is brought to the surface

Leave the spoon in the coffee

- As the metal is a good conductor and it is part submerged, it should help conduct heat from the liquid. Would it be better to put the spoon in "upside down" thereby increasing the surface area of the "radiant" end but minimising the surface area of heat collecting end?

Insert and remove the spoon repeatedly

- The spoon cools down more quickly when it's in the air.

Blow on the liquid

- The time honoured method, carrying hot air away from the surface of the liquid. But is it the best method?

Pour some of the liquid into the saucer, and then back into the cup

- Increases the surface are of the liquid in contact with the air
- Mixes hot and cold liquid
- This risks loss of liquid due to spillage hence the demand to record mass before and after the experiment

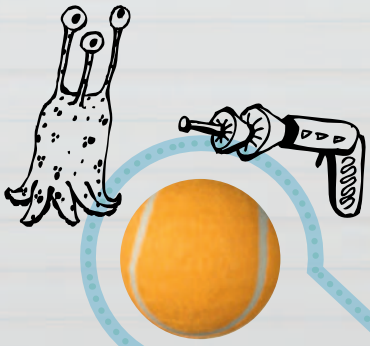
Or is the best solution a combination of the above .....

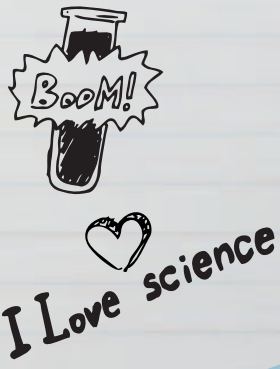
The ingenuity of the students is tested here!

The exercise lasts 10 minutes, after which time the temperature of the water is again noted, as is the total mass. Students are told that the difference in mass must be only 2% of the initial total or their data will be disqualified and the next lowest temperature is considered...

The winner will be the student whose "coffee" has cooled the most!

This student has to explain the physics behind their method for successful cooling!





Questions and extensions

1 Calculate the amount of energy exchanged with the surroundings during cooling, using the expression:

Energy = mass x specific heat capacity x temperature change

Water: shc = 4.18 J K^{-1} g^{-1}

Hence find the rate of energy exchange during the experiment. Is this likely to be constant?

2 Water has a high specific heat capacity which makes it useful for transporting and transferring energy around homes [in central heating for example]. Will dissolved substances affect this specific heat capacity? Explore what differences would be noted [if any] if the "coffee" were sweetened with two spoonfuls of sugar before conducting the cooling experiment. Describe a suitable procedure for investigating this.

3 Would the conditions in the room have a bearing on the results? What would be the effects [if any] of changes to ambient temperature, humidity or atmospheric pressure?

4 Could stirring the coffee actually heat it up? Research 'The Joule Effect'. Could the Joule Effect supply heat faster than the coffee cools? Use your answer to question 1 to help answer this.

5 To help explain what is happening in terms of energy transfer, you could try to create a thermogram by filming the test with an infra red camera (or even 'make' your own – http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/make-an-infra-red-camera/).

6 The teacher should carry out a "control" experiment using the same volume of water at the same temperature, but just leaving it with the spoon immersed. After 10 minutes the temperature would be recorded to give a comparator for the students' results.