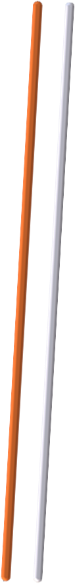
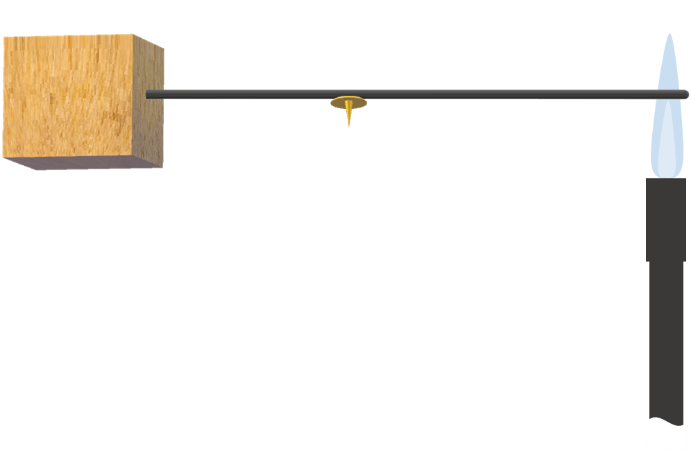
**Hot rods**

Metals are good thermal conductors.

****Do metals all conduct as quickly as each other?

Does glass conduct as well as metal?

****

**Predict**

Do you think one metal is a better thermal conductor than the other?

Do you think glass is a good thermal conductor?

**Explain**

Why do you think you are right?

|  |
| --- |
| **Now carry out the investigation** |

**Observe**

For each rod record the time taken for the drawing pin to fall off.

**Explain**

Were your prediction and explanation correct?

If not, can you explain what you observed?

*Physics > Big idea PMA: Matter > Topic PMA1: Heating and cooling > Key concept PMA1.3: Thermal conduction*

|  |
| --- |
| **Response activity** |
| **Hot rods** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Heating makes the particles in a material move more quickly. Heating raises the temperature quickly throughout a good thermal conductor, and very slowly through a good thermal insulator. |
| Observable learning outcome: | Identify materials that are good thermal conductors or good thermal insulators |
| Activity type: | Predict, explain, observe, explain - practical/demonstration |
| Key words: | Conductor, insulator, temperature, heating |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic question:

* Diagnostic question: Conductor survey

**What does the research say?**

Students are typically very good at identifying materials that are thermal conductors or insulators, and recognise in particular that metals are good conductors. However, this does not mean that students have a clear understanding of conduction and insulation. It is fairly common for students to describe good conductors as materials that heat or cool quickly (Erickson and Tiberghien, 1985). This is subtly different to understanding that energy is quickly transferred through a conductor by heating.

Students often link properties of an object with what will happen: if it feels cold it will cool, and if it feels warm it will warm. In a study Chu et al. (2012) found that more than a quarter of 14- to 16-year olds (n=344) thought that materials like wool have the ability to warm things up. The scientific approach is to consider the system, to identify where the temperature is higher and to consider how the energy can be transferred by heating to where the temperature is smaller.

This activity measures the time taken for energy to move along rods by heating, until the temperature is sufficient to melt Vaseline.

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

To begin, each group should discuss the activity and use their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now carry out the practical, or watch a demonstration. You will need to decide whether it is better for each group to carry out the practical and risk some unexpected observations, or to demonstrate the activity so that everyone *observes* the same thing.

After the practical each group should be given the opportunity to change, or improve their explanation. A good way to review your students’ thinking might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

A useful follow up is for individual students to then write down explanations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the each group. For example, you may choose to select a student with strong prior knowledge as a scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Equipment**

For each student/pair/group:

* X3 rods of equal dimensions (two made from different kinds of metal and one of glass)
* wooden block to hold a rod
* clamp, boss and stand
* Bunsen burner
* heat resistant mat
* drawing pin
* a little Vaseline (petroleum jelly)
* tongs
* timer

**Technician notes**

A wooden block is used to hold the rod whilst it is being heated. The block has a hole drilled into it into which the rod fits and the block is held in place with a clamp, boss and stand.

5 cm

The rod needs to fit securely, but be loose enough to place in and out of the hole without it sticking when it is hot (and has expanded).

Clamping at a slight upwards incline works well.

*In alternative methods for this investigation: holding rods directly in a clamp can burn the padding on the clamp; resting rods on a tripod allows heat to conduct through the tripod and affects the results.*

The drawing pin is stuck onto the bottom of the rod with a small blob of Vaseline, at a set distance from the end. The Bunsen is used to heat the rod at the end farthest from the wooden block. The time for the Vaseline to melt and the drawing pin to fall off is measured.

This is a good practical for developing Bunsen skills. In particular: adjusting the apparatus to heat at the hottest part of the flame; moving the Bunsen into and out of position holding it by its cool base at the gas inlet; arranging the apparatus so the gas tube is not stretched or in the way at any point.

**Health and safety**

Risk of burning. Hot rods should be removed with tongs and placed on a heat resistant mat to cool, which is in the centre of the table. Bunsen burners should be held at their base. When not being used to heat, the Bunsen burners need to be adjusted to the safety flame.

The glass rod can glow red hot at the end before the drawing pin drops off. Students could heat the glass rod last and leave it in the wooden block to cool down for several minutes before they remove it. Perhaps instruct students to heat any one rod for a maximum of three minutes.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

The metal rods are both good thermal conductors, but one will be better at conducting than the other. They have a different structures and are made of different types of atoms and so it is unlikely that they have exactly the same properties.

The glass rod is a poor thermal conductor and the drawing pin may not fall off at all. Non-metals are often poor conductors, but metals are all good conductors.

*Glass is a better thermal conductor than most insulators, which is why it feels cold to the touch. Diamond is a non-metal that conducts better than any metal. Diamonds are called ‘ice’ because when you hold a large diamond it feels* ***very*** *cold because of how well conducts body heat away.*

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Chu, H.-E., et al. (2012). Evaluation of Students' Understanding of Thermal Concepts in Everyday Contexts. *International Journal of Science Education,* 34:10**,** 1509-1534.

Erickson, G. and Tiberghien, A. (1985). Heat and Temperature. In Driver, R., Guesne, E. & Tiberghien, A. (eds.) *Children's Ideas In Science.* Milton Keynes and Philadelphia: Open University Press.