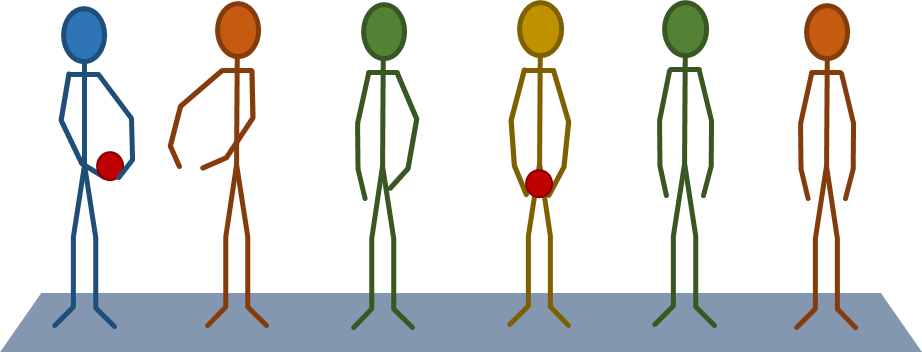
**Along the line**

Some students are modelling thermal conduction in metal.

They want to show how the freely moving outer electrons from metal atoms enable a metal to conduct quickly.



**To answer**

1. State three ways in which this **is a good representation** of thermal conduction in metal.

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

1. State three ways in which this is **not an accurate representation** of thermal conduction in metal.

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

1. Describe a better model to show thermal conduction in a metal.

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

……………………………………………………………………………………………………………………………………………………

*Physics > Big idea PMA: Matter > Topic PMA3: Energy of moving particles > Key concept PMA3.1: Transfer of energy by conduction*

|  |
| --- |
| **Response activity** |
| **Along the line** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Energy is transferred through a solid away from regions of higher temperature as its particles are caused to vibrate more vigorously. |
| Observable learning outcome: | Describe the mechanism of thermal conduction that can occur in all solids.  Explain why metals are good thermal conductors. |
| Activity type: | Critiquing a representation |
| Key words: | Thermal conduction, outer electron, heat, energy, particle, vibrate |

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

* Diagnostic question: Heating spoons
* Diagnostic question: Fast conduction

**What does the research say?**

The notion that heat and cold are material substances that can flow from one place to another seem to be both common and persistent (Engel Clough and Driver, 1985; Hatzikraniotis et al., 2010; Thomaz et al., 1995). Engel Clough and Driver (1985) found that almost all 12- to 16-year-olds understood that ‘heat’ travelled through metals, but often described heat flowing rather than the actual mechanism. Hatzikraniotis et al. (2010) reported that the majority of 13- to 14-year-olds (n=24) described thermal conduction as the flow of hot particles. In their study in Portugal, Thomaz et al. (1995) similarly found that before teaching, 42% of 14- to 15-year-olds (n=79) wrongly thought of ‘heat’ (or ‘cold’) as a substance.

Metals are good thermal conductors because the outer electrons of metal atoms can move freely in-between metal ions. In thinking about how these outer electrons make metals good thermal conductors Pathare and Pradhan (2010) found some second year undergraduate physics students wrongly thought the heating of one end of a metal rod *released* more electrons from atoms to flow along it.

**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.

Philosophically science can be said to be a description of the ‘best model’ we have for the world. In this activity students should identify ways in which this particular model is a good representation of the real world, and ways in which it is not.

The model is not a particularly good one and needs some modification to become one. The third question is one that students should perhaps focus on the most.

Students should work together to answer the questions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

Ending with the students completing the worksheet or questions from the PowerPoint individually, might help them to consolidate their learning.

*Differentiation*

You may choose to use simplified worksheets for some students, for example with gaps to fill in so they can focus on the science. In some situations it may be more appropriate for a teaching assistant to read and/or scribe for one or two students.

**Expected answers**

1. The students are stood close together in a regular order like metal ions.

The balls move ‘through’ the metal like freely moving outer electrons.

The balls are much smaller than the students and freely moving outer electrons are much smaller than ions.

2. When the metal is hotter its ions vibrate more vigorously and here the students are not vibrating at all.

Freely moving outer electrons move freely between the ions and may whiz passed several at one time.

Freely moving outer electrons should hit ions and make them vibrate more vigorously.

The ions should also pass on vibrations by bumping into each other, although the freely moving outer electrons move along much more quickly.

3. Perhaps put several balls on the floor in a confined space (the metal) and students jiggle about a little tapping the balls so they move about a little. The balls are like the freely moving outer electrons between the metal ions.

When one end of the metal is heated the students (ions) at that end jiggle about more and kick the balls harder.

Students hit by a fast moving ball jiggle about more vigorously too and also kick the balls harder.

Ions also jiggle harder if adjacent ions jiggle into them.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Engel Clough, E. and Driver, R. (1985). Secondary students' conceptions of the conduction of heat: bringing together scientific and personal views. *Physics Education,* 20**,** 176-182.

Hatzikraniotis, E., et al. (2010). Students' design of experiments: an inquiry module on the conduction of heat. *Physics Education,* 45 (4)**,** 335-344.

Pathare, S. R. and Pradhan, H. C. (2010). Students' misconceptions about heat transfer mechanisms and elementary kinetic theory. *Physics Education,* 45**,** 629-634.

Thomaz, M. F., et al. (1995). An attempt to overcome alternative conceptions related to heat and temperature. *Physics Education,* 30 (1)**,** 19-26.