**Beyond ‘beyond’**

Infrared, visible light and ultraviolet are types of electromagnetic (EM) radiation.

The table provides information about each of these.

|  |  |  |
| --- | --- | --- |
| ***EM radiation*** | ***Approximate frequency*** | ***Speed in a vacuum******(empty space)*** |
| Infrared | 0.3-400 THz | 3 x 108 m/s |
| Visible light | Red, 400-480 THz  | 3 x 108 m/s |
| Violet, 670-790 THz | 3 x 108 m/s |
| Ultraviolet | 790-30000 THz | 3 x 108 m/s |

*1 THz = 1 terahertz*

 *= 1 000 000 000 000 Hz*

 *= 1 x 1012 Hz*

What do you think about EM radiation?

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | There are more than 3 types of EM radiation. |  |  |  |  |
| **B** | All EM radiation travels at the same speed. |  |  |  |  |
| **C** | All EM radiation travels through glass. |  |  |  |  |

*Physics > Big idea PSL: Sound, light and waves > Topic PSL7: Electromagnetic waves > Key concept PSL7.1: More than light*

|  |
| --- |
| **Diagnostic question** |
| **Beyond ‘beyond’** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Electromagnetic radiation is made of vibrating electric and magnetic fields that can travel through a vacuum. Light and other types of EM radiation are organised in order of frequency across the EM spectrum. |
| Observable learning outcome: | Explain why there is a spectrum of electromagnetic radiation. |
| Question type: | Confidence grid |
| Key words: | Electromagnetic radiation, vacuum, frequency, hertz, oscillations per second |

**What does the research say?**

Most students, age 12-18, do not consider light to be radiation (Rego and Peralta, 2006; Neumann and Hopf, 2012). The BEST key concept: *PSL6.1 Refraction and dispersion* develops understanding of the wave model of light, which can be extended by considering what can be observed beyond either end of the visible spectrum, which is recommended by Neumann (2014).

Libarkin et al. (2011) found that, prior to teaching, very few students were familiar with infrared (IR) radiation, found a little beyond the red end of the visible spectrum, and most were unable to explain what it was or describe its characteristics. Students tend to be more aware of ultraviolet (UV) radiation, but the majority of those aged 11-18 (n=283) were found to have the misunderstanding that the Sun is the only source of ultra-violet radiation (Libarkin et al., 2011), which suggests their knowledge of UV is perhaps linked to tanning and to the risk of sunburn.

This question checks students’ awareness of further types of EM radiation and their understanding that the type of EM radiation is determined by its frequency.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statement A is right, and statements B and C are wrong.

**How to respond - what next?**

The possible range of frequency of EM radiation is from zero to infinity. The table shows only a portion of this range and is missing EM radiation with a frequency below 0.3 THz or above 30 000 THz. Radio waves and microwaves have frequencies below 0.3 THz and X-rays and gamma radiation frequencies above 30 000 THz.

All EM radiation travels at the same speed in a vacuum, but at different speeds through materials that they can travel through, the types of which vary depending on the type of radiation. Not all EM radiation travels through glass.

A Students may not be aware of other types of EM radiation or they may not realise that EM radiation can have any frequency beyond the range indicated.

B It is often stated that all types of EM radiation travel at the speed of light in a vacuum. Some students may misunderstand this to mean that all types of EM radiation always travel at the same speed, and a few may not understand what is meant by a vacuum.

 It is likely that students will interpret this statement to be comparing the speed of EM radiation in a vacuum, but this is not stated.

C It is common for students to think that glass is transparent to all types of EM radiation. They may think that, because all EM radiation consists of oscillating electric and magnetic fields, all frequencies will interact with glass in the same way and pass through. This is not true and the way EM radiation interacts with a material is partly determined by the nature of oscillations that it can cause within the material.

If students have misunderstandings about explaining why there is a spectrum of electromagnetic radiation, it can help to discuss the nature of the different EM radiations given in the table, in terms of what they have in common (EM oscillations) and ways in which they are different (frequency, the way in which each one interacts with matter and the way in which each one is detected). The discussion could be extended to consider, in a similar way, the EM radiations that have higher or lower frequencies.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

**References**

Libarkin, J. C., et al. (2011). Invisible misconceptions: Student understanding of ultraviolet and infrared radiation. *Astronomy Education Review,* 10(1).

Neumann, S. (2014). Three misconceptions about radiation—and what we teachers can do to confront them. *The Physics Teacher,* 52(6)**,** 357-359.

Neumann, S. and Hopf, M. (2012). Students’ conceptions about ‘radiation’: Results from an explorative interview study of 9th grade students. *Journal of Science Education and Technology,* 21**,** 826-834.

Rego, F. and Peralta, L. (2006). Portuguese students' knowledge of radiation physics. *Physics Education,* 41(3)**,** 259.