

Workshop Tutorials for Introductory Physics

WI5: The Electromagnetic Spectrum

A. Review of Basic Ideas:

Use the following words to fill in the blanks:

night, sun, heat, $3 \times 10^8 \text{ m.s}^{-1}$, spectrum, blue, rods, cones, electromagnetic, butterflies, microwaves, sound, wavelengths, visible, red, cows, ultraviolet, grey

Light and the Electromagnetic Spectrum

Have you ever stopped to think how it is that the information on this sheet reaches you? The answer lies with the waves that reflect off the sheet and into your eyes. These waves are electromagnetic in nature and your eyes respond to a particular range of frequencies – the visible segment of the electromagnetic _____.

Radio waves, _____, infrared radiation, visible light, ultraviolet, x-rays, gamma rays are just some of the common members of the electromagnetic spectrum. All these _____ waves have the same nature – they are comprised of oscillating electric and magnetic fields. Electromagnetic waves travel (propagate) at a constant speed of _____ in a vacuum. These waves do not need a medium, unlike _____ waves they can move through a vacuum. The energy the earth receives from the sun is electromagnetic in nature and comes to us through space.

What then is the difference between the different parts of the spectrum? The answer is that different parts have different frequencies and so different _____ but they all travel with the speed of light.

Humans are sensitive to only a very small part of the electromagnetic spectrum. With our eyes we detect _____ light, and with our skin we can detect infrared radiation, or _____. Human retinas have four types of detector cells, three types of _____ for colour vision, and the _____. The rods are very sensitive and are used mainly for spotting movement in the peripheral vision and for _____ vision. The rods don't tell different colours apart, which is why everything looks sort of _____ at night.

The three types of cones are sensitive to different wavelengths, or colours, one to blue, one to green and one to red. The sensitivities overlap so that we can see light from the _____ end of the spectrum, around 400 nm, to the _____, around 700 nm. We are most sensitive to the green/yellow around 550 nm, which is now being used on emergency vehicles such as fire engines rather than the traditional red. This is also the frequency at which the _____ radiates the most light.

Some animals don't have colour vision at all, such as _____ and dogs. Others have very different colour vision, such as insects. Bees are sensitive to _____, and many _____ see infrared.

Discussion Question

Can Superman really use x-ray vision? What would he need to be able to see with x-rays?

B. Activity Questions:

1. Speed of Light

Microwave the marshmallows to find the speed of light!

Read the frequency of the microwave radiation produced from the back of the microwave.

Microwave the marshmallows, watching carefully, and stopping the oven when they first begin to melt.

Measure the distance between melted bits to find the wavelength, and use this to calculate the speed of light.

Warning – very hot! Do not touch the molten marshmallows!

2. Prism

Shine the light through the prism.

What do you see going into the prism?

What do you see coming out?

Which is refracted (bends) more – light of long or short wavelength?

3. Change the colour of your fruit (or See the World through Rose Coloured Glasses)

Look at the banana with the red glasses. What do you see?

How does it look through the green glasses?

What about the apples? How do they look through the different glasses?

4. Sunset in a jar

Look at the light transmitted through the top of the beaker.

What do you notice about its colour?

What do you notice about the light coming out the sides of the beaker?

Explain the difference in these colours.

Explain why the sky on Earth is blue. What colour do you think the sky is on Mars? Why?

C. Qualitative Questions:

1. Rebecca and Brent are sitting inside watching TV one evening when Brent notices a lightning flash. A few moments later they hear a peal of thunder. Brent says they'd better go bring the washing in off the line because there's a storm coming. Rebecca's says to wait until the next ad' break. "hmm..." say's Brent, as he listens to the next peal of thunder, "that storm is getting pretty close, the thunder was only a second after the lightning".

"How can you tell?" asks Rebecca, as the first drops of rain start to fall...

How can Brent tell that the storm is getting closer? Explain your answer.

2. When some people go shopping for clothes they try to look at the clothes in natural light, for example in the doorway of a shop. Why do you think they do this? Why do you think expensive clothing shops rarely use fluorescent lighting in their fitting rooms?

D. Quantitative Question:

FM radio stations broadcast signals which have frequencies in MHz, for example 106.5 MHz.

a. Find the wavelength of the signal broadcast by this station.

AM radio stations broadcast in the "medium wave" range, which is much lower frequency than FM stations.

b. Which radio station in Sydney broadcasts a signal with a wavelength of 521 m?

There are two ways in which radio stations transmit signals to your car radio – one is AM or amplitude modulation, the other is FM or frequency modulation.

c. Draw a diagram showing the difference between amplitude modulated and frequency modulated waves.