

TEACHER'S GUIDE
SCIENCE KEY CONCEPTS SERIES: PHYSICS
THE ELECTROMAGNETIC SPECTRUM
15 minutes, Video

Distributed by BENCHMARK MEDIA

FOR USE IN: General Science, Physics

LEVEL: Grades 7-12

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EDUCATIONAL OBJECTIVES:

To help the student understand these key concepts about the electromagnetic spectrum:

- The gradations and nature of wavelengths along the electromagnetic spectrum: visible waves, longer and shorter waves.
- Visible light: primary and secondary colors; and white light.
- The characteristics and uses of longer and shorter wave frequencies.

BEFORE SHOWING THE VIDEO: The three key concepts in this video are:

1. The Visible Spectrum 2. Longer Waves 3. Shorter Waves

To play only concepts #2 or #3, simply fast-forward to its title. Each concept runs about 4-5 minutes.

Laboratory demonstrations shown are generally too difficult, dangerous, or expensive to do in the classroom. Excellent computer graphics and superimposed text, clarify and explain what is happening during the experiments. Some questions posed during the video, may provide the basis for discussion after the video.

Obtain a prism and pass a beam of light through it from a very bright incandescent lamp such as a high intensity flashlight or other directed light source, or by directing a ray of sunlight through the prism. Place a white sheet of paper at a suitable distance to obtain a good image of the visible spectrum. If you do not have a prism, the light can also be passed at an appropriate angle through the corner of a rectangular aquarium filled with water to obtain a good spectrum. The room may need to be partially darkened for best results. Ask the students to offer explanations of why the apparently white light becomes separated into the rainbow-like pattern of hues. List some of the suggestions for later reference. Place some colored objects such as pieces of grass, an orange, etc. on the paper so that each is successively illuminated by different colors in the spectrum produced by the prism. Ask the students to describe and explain their perception of the hue of each object when it is illuminated by each of the different color bands of the spectrum. Encourage the students to offer explanations for why the colors of the objects look different when viewed with "white" light compared to their appearance when illuminated by the various color bands in the color spectrum. In addition, if you have some colored transparent cellophane paper, or colored light filters, pass white light through the filters and ask the students to note the color they see. Invite explanations of what is happening when the white light passes through such a color filter. Further, illuminate some of the commonly encountered colored objects

recommended above with the filtered light of different colors and encourage the students to describe the differences in the hues they perceive compared to that in white light. Ask them to suggest explanations for the differences. Invite them to observe the video for a scientific explanation of what is happening when we see colors, and how invisible radiation such as ultra-violet, infrared light, radio waves, and x-rays can help us better visualize our environment through modern technology. It is important to be aware that some of your students may be visually impaired or color blind and make adequate provision or their sense of well being and acceptance during this learning experience.

CONTENT OF THE VIDEO

The Visible Spectrum

Demonstration of white light being shone through a prism. It splits into the colors of a [rainbow](#): the [visible spectrum](#).

When the spectrum is passed through another prism, the colors add together again to give white. When white light is shone through a red filter, it only lets through the red part of the spectrum. All the other colors are absorbed by the filter. The primary colors are red, blue and green. We see how [mixing colors](#) in different proportions can make any new colour. For example, mixing green and blue gives cyan. A giant television screen is used to show how we can build up a picture. Each element of the picture (or *pixel*) has lights, which show each of the primary colors. From a distance, the colors mix and the pixel appears to be, for example, cyan when the green and blue lights are on. The whole picture is made from a giant array of these pixels, which can change rapidly to display a moving image.

Visible light is a [wave](#): part of the [electromagnetic spectrum](#). The wavelength of the light determines its color. Red has the longest wavelength (about 700 nm) and violet has the shortest wavelength (about 400 nm).

Longer Waves

Other parts of the electromagnetic spectrum have been [discovered](#) over the last century. They have different [frequencies and wavelengths](#). A detector picks up some radiation in the region beyond the red light given off by a lamp. It is detecting infrared radiation. Infrared radiation is given off by anything warm, and we can feel it because it heats up our skin. It is sometimes called 'radiant heat'. An infrared camera detects infrared radiation and can display a picture of it on a television screen. We see a light bulb which shows up on the camera as it is warming up but before it is hot enough to glow. A person's warm body gives off infrared radiation. So police can use infrared ([thermal imaging](#)) cameras to follow people in the dark.

Beyond infrared radiation is microwave radiation, which has a higher wavelength (about 3 cm). One particular wavelength causes water molecules to resonate and heat up their surroundings. This wavelength is used in microwave cookers.

Microwaves (excluding the one wavelength above) are also used to carry satellite television pictures, trunk telephone calls and some mobile phone calls. Microwaves are blocked by a hand so they need a line of sight to carry their signals.

The longest waves in the electromagnetic spectrum (up to 3 km) are [radio waves](#). These can be [broadcast](#): they don't need a line of sight and will travel around obstacles to reach everyone's radio set.

Shorter Waves

Some rocks and other substances are seen to glow - or *fluoresce* - when ultraviolet radiation falls on them. Although ultraviolet radiation isn't visible, its presence can be detected by [fluorescence](#). Ultraviolet radiation has a lower wavelength and higher frequency than visible light. It is absorbed by fluorescent material, which then gives out radiation with a lower frequency in the visible part of the electromagnetic spectrum. [Fluorescent tubes](#) are coated on the inside with fluorescent paint. The gas discharge inside the tube emits ultraviolet and some blue radiation. It looks pale blue without the fluorescent coating, but in the coated region the ultraviolet radiation makes the paint fluoresce and glow white.

Ultraviolet radiation tans the skin and is used in sun beds. But the ultraviolet radiation from the Sun can be damaging, particularly in areas of the world where the [ozone layer](#) of the atmosphere, which absorbs harmful ultraviolet rays, has been thinned.

Beyond ultraviolet, there are even shorter waves called X-rays. They have a wavelength of about 1 nm. They penetrate most materials, to varying degrees, but are stopped by metal. The programme shows how they are used to look inside people's luggage at airports.

X-rays are partially stopped by bone, but pass through flesh. We see how they can be used to take a photograph inside a patient.

The smallest wavelength in the electromagnetic spectrum belongs to [gamma radiation](#). We see how it can be used to monitor blood flow in a patient's brain. The patient is injected with a substance that is emitting gamma radiation. A special camera can then detect the gamma radiation and follow the substance as it is carried by blood through the patient's brain.

AFTER VIEWING THE VIDEO QUESTIONS AND ACTIVITIES:

What evidence indicates that white light is composed of a mixture of colors varying in frequency? (The refraction of white light passing through a prism into different frequencies at slightly different angles producing a spectrum of colors)

What everyday evidence is there that sunlight includes waves invisible to our eyes? (we feel longer infra-red waves as heat, and we get sunburned from shorter ultra-violet waves)
Based on their wavelengths, list the categories of electromagnetic radiation from shortest to longest.

How is the production of Gamma waves different from other electromagnetic radiation?
(gamma rays are produced by the decay of the unstable nucleus of a radio-active atom, whereas all the other forms of electromagnetic radiation are produced by vibrations of the electrons surrounding the nucleus of stable atoms)

What are characteristics common to all electromagnetic waves? (travel at the speed of light, have frequency and wavelength, the higher the frequency the higher the energy, the energy is partly electric and partly magnetic)

INTERNET WEB SITES FOR FURTHER INFORMATION ON:

Color: Activities on using prisms and making rainbows.

<http://accept.la.asu.edu/PiN/rdg/color/color.shtml>

Color mixing: Computer displays with further information on colour and other areas of physics. <http://www.osc.on.ca/InteractiveZone/Pixels/pixelcol.htm>

Discoveries of the electromagnetic spectrum: Some history and descriptions of the different regions of the spectrum. (<http://www.ultisoft.demon.co.uk/spectrum.html>)

<http://www.geo.mtu.edu/rs/back/spectrum/>

Fluorescence: Brief description. <http://www.aspsky.org/html/tnl/35/atom.html>

Fluorescent sources: Good description of fluorescence, with further information on the properties of light.

http://cyberscol.qc.ca/classes/physique/p1/chapter1/1_Sfluor.html

Gamma radiation:

http://www.channel4.com/schools/online_resources/netnotes/sifpp2/sifpp2nn4.html

Ultraviolet: Ultraviolet, infrared and fluorescence are all discussed in an article called There's more to light than meets the eye.

<http://www.aspsky.org/html/tnl/35/35.html>

Visible spectrum: Colourful representation.

<http://www.scimedia.com/chem-ed/light/em-spec.htm>

Ten titles in the Science Key Concepts Series are: Cellular Energy and Metabolism, Cells and Tissues, Energy Transfer, Biogeochemical Cycles, Waves, The Electromagnetic Spectrum, Electricity and Magnetism, Molecular Motion, Electro-Chemistry, The Reactivity of Elements, The Uses of Natural Resources.

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