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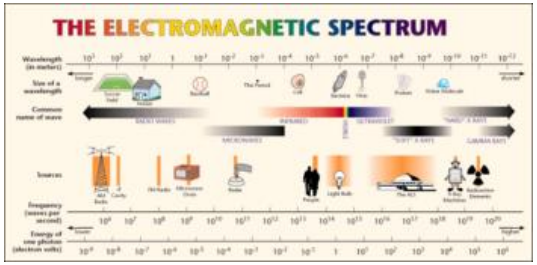
Waves and Rays, Part I

By Cindy Grigg

Have you ever played in the ocean? The waves can push you around. They can pull the sand out from under your feet. As far out as you can see, there are more waves coming at you all the time.



There are other kinds of waves all around you all the time. You can't see most of them, but they can warm you, burn you, and go right through your body. These are the waves of the electromagnetic spectrum.

These waves come from the same kind of electric force that makes your TV work and from the same kind of magnetic force that holds the picture you drew in art class on your kitchen refrigerator with a magnet. When these two forces act together, they make electromagnetic radiation. This is a kind of energy that is both electric and magnetic. This energy travels in waves.

In some ways, these waves and ocean waves are alike. They have tops called crests. They have bottoms called troughs. The distance from one crest to the next is called a wavelength. Wavelengths can also be measured from one trough to the next. Another way electromagnetic (EM) waves are like ocean waves is that they both move energy from one place to another.

The biggest difference between ocean waves and EM waves is that ocean waves move across water. Energy moves through the water. EM waves don't need anything to move through. They can move across the emptiness of outer space. In outer space where there is nothing for the waves to move through, the waves travel at the speed of light. EM waves can also travel through things. They can travel through air inside a room, around the earth, or through food. Some EM waves can even travel inside your body!

Let's learn more about these mysterious waves. When you turn on a radio, you're using part of the EM spectrum. Radio waves have the longest wavelengths of any of the waves in the EM spectrum. Radio waves can be several miles long, or they can be about the length of a one-foot ruler.

When you turn the dial on the radio, you are changing from one radio frequency to another. Frequency means how many waves pass a certain point in one second. If you could see radio waves, you could stand on the street outside your house and count them. Imagine there is a radio tower at the end of your street. The tower sends out radio signals. If you could see the radio waves, you could count how many of them pass a point in front of you in one second. A single wave from one crest to the next (or one trough to the next) is called a cycle. If five thousand waves passed the point in front of you in one second, the radio signal would have a frequency of five thousand cycles per second. You'd have to be able to count pretty fast!

Another name for cycle per second is hertz. It is abbreviated Hz. Radio waves are used to broadcast radio and TV shows and signals for cellular phones, pagers, and beepers. They carry signals here on Earth and through outer space.

There are seven different types of EM. The frequency of the waves makes each type different. Frequency is the number of cycles that pass a given point in one second. The example above (where you counted radio waves from a tower) had a frequency of five thousand cycles per second. Waves in the EM spectrum that have the lowest frequencies have the least amount of energy. Waves with the highest frequencies have the most energy. The first type we learned about is radio waves. The other six types are microwaves, infrared, visible light, ultraviolet, X rays, and gamma rays.

Microwaves are shorter waves than radio waves - shorter than 11.8 inches. The ones used in microwave ovens to cook food are about five inches long. How do microwaves cook food? When you put food into a microwave, the plate stays cool and the food gets hot. Inside food is water. Plates don't have water inside them. When the microwaves hit the food, the water inside the food begins to vibrate from the energy. Microwaves have a frequency of two billion four hundred fifty million waves per second. The water molecules vibrate with that same frequency. When molecules vibrate, they move. The movement releases heat inside the food. The heat cooks the food very quickly.

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Two billion four hundred fifty million waves per second is a really big number. Scientists needed a shorter way to say it. A million cycles is a megahertz, abbreviated MHz. A thousand megahertz, or 1000 MHz, is the same as saying one billion cycles per second. The frequency of a microwave can be written as 2450 MHz. Microwaves are also used for communication and TV satellites and for radar. These have shorter waves than those used for microwave ovens. Communications satellite microwaves can be as short as four-hundredths of an inch. When a wavelength is that short, the frequency is high - three hundred billion cycles per second. This can be written as 300 GHz, or 300 gigahertz. "Giga" means one billion.

Infrared waves are the next ones in the band of EM radiation. If you stand in the sunlight, you can feel warmth from the sun's infrared radiation. Your TV remote works on infrared waves. When you push a button on your TV remote, a microchip in the remote starts a vibration. It produces waves in the infrared range. Infrared waves have frequencies of 100 billion to 100 trillion cycles per second. Here's another prefix to learn: "tera" means one trillion. One terahertz (THz) is one trillion hertz or cycles per second. Since the frequencies of infrared beams are so high, the wavelengths are short-from four-hundredths of an inch to only four-hundred thousandths of an inch.

These infrared beams carry codes. Inside the TV set, another microchip identifies each code and sends a signal to raise or lower the volume, change channels, turn the set on or off, record a program, or do whatever you want it to do. Firefighters use infrared cameras to look through smoke and find survivors. They are used in building construction to find heating and cooling system leaks. They are also used in medicine to diagnose cancers and injuries, similar to X-rays.

Radio, microwaves, and infrared are only part of the waves that make up the EM spectrum. Read *Waves and Rays, Part II* to find out more.

Questions

_____ 1. All waves need some material to travel through.

A. true
B. false

_____ 2. Electromagnetic radiation is:

A. energy that is magnetic and solar
B. energy that is created only by the sun
C. energy that is electric and magnetic
D. energy that is created by atoms and electricity

_____ 3. EM waves have crests, troughs, and wavelengths.

A. false
B. true

_____ 4. Radio waves:

A. are the longest waves in the EM spectrum.
B. are the shortest waves in the EM spectrum.
C. carry the most energy in the EM spectrum.
D. need water to travel through.

_____ 5. What does frequency mean?

A. how many waves or cycles pass a certain point in one minute
B. how many waves or cycles exist at one time
C. how many waves or cycles pass a certain point in one hour
D. how many waves or cycles pass a certain point in one second

_____ 6. A cycle measures:

A. how much time it takes the wave to travel from its source to Earth
B. a single wave from one crest or trough to the next
C. how long the wavelength is
D. the number of waves passing a certain point in one second

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_____ 7. Another word for cycles per second is:

A. waves
B. EM radiation
C. frequency
D. hertz

_____ 8. Which waves have the highest frequencies?

A. microwaves
B. waves with the lowest energy
C. UV
D. waves with the highest energy

_____ 9. Radio waves are used for:

A. TV broadcasting
B. cell phones
C. pagers
D. all of the above

_____ 10. In general, if a wavelength is short:

A. the energy and frequency are high.
B. It tells us nothing about the energy and frequency.
C. the energy and frequency are low.
D. the energy and frequency are medium.

Explain how microwaves work to cook food.

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How are EM waves like ocean waves? How are they different?