

The Electromagnetic Spectrum

We're surrounded by light, radio waves, microwaves, and myriads of other types of electromagnetic radiation. This wide range of electromagnetic waves with different frequencies and wavelengths make up the **electromagnetic spectrum**. Electromagnetic waves vary in length from kilometers for radio waves to less than the diameter of an atom for X-rays and gamma rays. Visible light, the one we know best, is only part of the electromagnetic spectrum.

Radio waves are electromagnetic waves with wavelengths greater than about 0.001 m. They have the lowest energy and frequency of all electromagnetic radiation. Radio waves include TV signals, and AM and FM radio signals. They are produced in a broadcasting antenna by making electrons in the metal vibrate. These radio waves cause electrons in a receiving antenna to vibrate, creating an alternating current that is used to produce a picture on a TV screen or sound from a loud speaker. **Microwaves** are higher frequency radio waves with wavelengths between 0.3 m and 0.001 m. Microwaves warm food in microwave ovens by making water molecules vibrate faster. They're also used to transmit cell phone signals. Radar is an acronym for **RA**dio **D**etecting **A**nd **R**anging. Radar uses radio waves to detect objects by echolocation. A radar station sends out radio waves that bounce off an object. Electronic equipment measures the time it takes for the radio wave to reach an object, be reflected, and return. The speed of the radio wave is used to calculate the distance. Because of the high speed of the radio wave, the process takes only a fraction of a second.

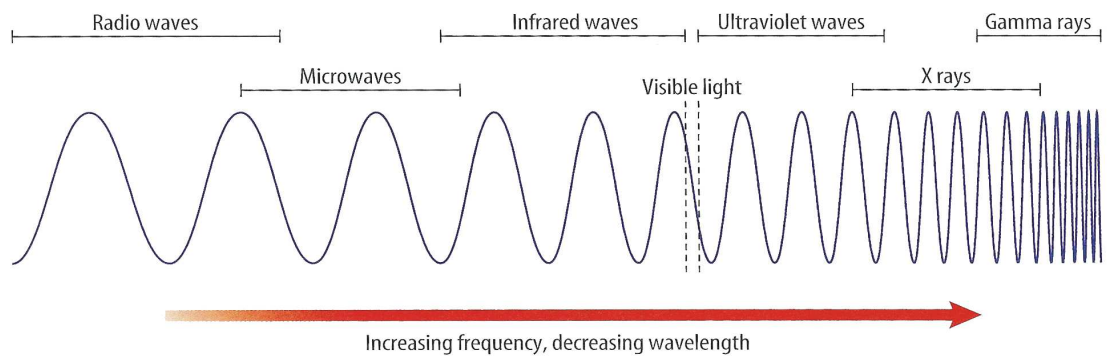
Infrared waves are electromagnetic waves with wavelengths between 1,000 μm and 0.7 μm . They are emitted all objects, and detected as heat. Most electromagnetic energy given off at room temperature is infrared radiation with a wavelength of about 10 μm . Infrared detectors detect objects that are warmer or cooler than their surroundings. Satellites with infrared detectors can be used for mapping forests, water, rocks, and soil. Forests and areas covered with vegetation tend to be cooler than their surroundings. Night vision devices use infrared. Snakes such as pit vipers have a pit located between the nostril and the eye that helps them hunt by detecting infrared.

Visible light consists of electromagnetic waves with wavelengths between 0.7 μm and 0.4 μm . Different colors have different wavelengths. Red light has the longest wavelength and the lowest frequency. Blue light has the shortest wavelength and the highest frequency.

Most objects that you see do not give off visible light, but they reflect it. The most intense light given off by the sun is visible light.



Frequency follies



Ultraviolet radiation has electromagnetic waves with wavelengths between $0.4 \mu\text{m}$ and $0.01 \mu\text{m}$. It has a shorter wavelength, higher frequency, and more energy than visible light. Ultraviolet radiation can kill or damage cells. Exposure over time can lead to early aging of the skin and to skin cancer. The body's natural defense against ultraviolet radiation is to tan. Ultraviolet enables humans to produce vitamin D. It is used to disinfect and sterilize equipment. Most UV light arriving at the Earth is absorbed by the ozone in the upper atmosphere. The atmosphere also absorbs higher energy radiation such as X-rays and gamma rays, but is transparent to visible light and radio waves, and partially transparent to infrared waves.

X-rays have a higher frequency than UV light, and **gamma rays** have a higher frequency than X-rays. As a result, X-rays have higher energy than UV light and gamma rays have higher energy than X-rays. They both have a greater ability to penetrate and damage cells than UV light with gamma rays being worst. X-rays are used to produce images on a film (an X-ray) in order to detect injuries, and disease such as broken bones and cancer. X-rays pass easier through less dense tissues, and are absorbed by bone. As a result, X-rays strike a film creating a shadow of denser tissue. CT scans are X-ray images of the human body as if it had been sliced. Gamma rays can be used to kill cancerous tumors and bacteria in food.

Answer the questions below based on the reading above and on your knowledge of physics.

1. What is the electromagnetic spectrum? _____

2. List the main types of electromagnetic radiation in order of decreasing wavelength. _____

3. What kind of electromagnetic radiation is given off by all objects? _____
4. What kind of electromagnetic waves easily pass through the atmosphere? _____

5. What kind of electromagnetic waves have the highest energy? _____

6. What are some uses of radio waves? _____

7. What makes it obvious that radio waves pass easily through walls? _____

8. How does radar work? _____
