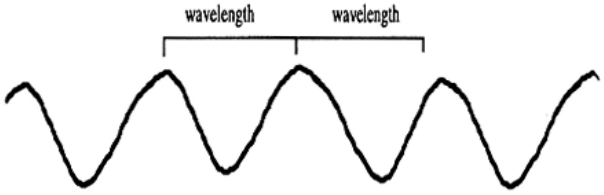
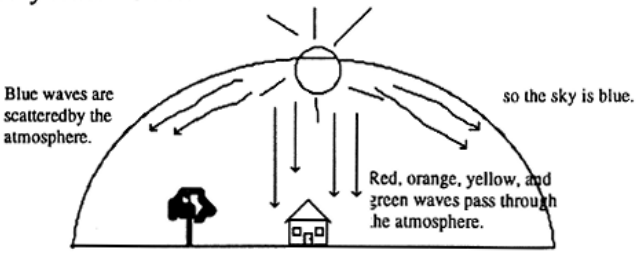
3.1 Electromagnetic Spectrum

Visible light is a mixture of all colors. The wavelength of visible light determines its color. **Wavelength** is the distance between two adjacent wave crests. Wavelength can be expressed in Angstroms (Å), nanometers, centimeters, meters, etc. The symbol for wavelength is λ.

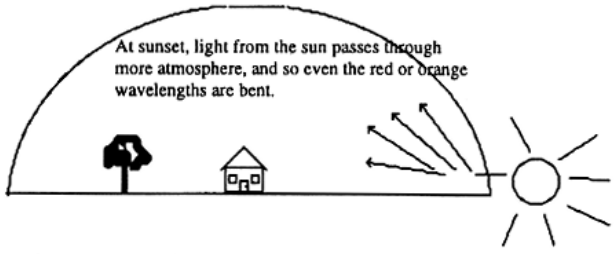


Violet light has the shortest wavelength of visible light, 3800Å or 380 nm, and red light has the longest wavelength, 7600Å or 760 nm. When white light is passed through a prism, violet light, with the shortest wavelength, is refracted the most, and red light, with the longest wavelength, is refracted the least. This is because the speed of the light varies in different mediums. Whenever you see a rainbow, you are witnessing this effect. The water in the atmosphere acts like a prism to create rainbows.

This phenomenon explains why the sky is blue during the day. When the sun is overhead at mid-day, the atmosphere scatters blue light (shortest wavelength), and the red light is not scattered, so the sky looks blue.

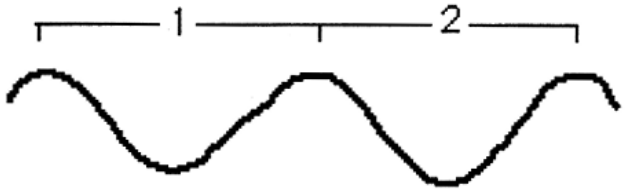


At sunset, the increased atmosphere through which the light must travel, causes the red light to be refracted too.



If the sky is cloudy or dusty, red rays are refracted making the sky red and giving a magnificent sunset. Have you ever noticed that sunsets are much more brilliant than sunrises? This is because winds and heat of the day whip up dust. The greater the concentration of dust, the more light is scattered. Oceans and lakes are blue although water in a drinking glass is colorless. This is because of light scattering. The scattered light of the atmosphere penetrates the water in the oceans and lakes. In clear, deep water, the light is reflected back as blue. Lakes that are clear and shallow are greenish colored because the light is reflected back from the bottom of the lake. Light is not reflected back from turbid or muddy lakes because the particles in the lakes absorb the light. Minnesota is called the "Land of Sky Blue Waters" because of its deep, clear lakes reflect back blue light.

Visible light is only one part of the electromagnetic spectrum and is the only part which can be seen. **Radio waves** are part of the electromagnetic spectrum (EM spectrum). Heinrich Hertz discovered radio waves in 1887 and called them radio waves because they were "waves that radiate." The Italian inventor Guglielmo Marconi made the first radio transmitting equipment in 1890. Today we receive radio waves on FM or AM radio. FM is broadcasted in radiowaves in MHz = megahertz = 1,000,000 cycles per sec, whereas AM stations broadcast in KHz = kilohertz = 1000 cycles per second. Each station has a particular wavelength and frequency assigned to it so that you can listen to the channel of your choice without interference from other waves. **Frequency** is how often a wave crest passes a given point in a given amount of time. Frequency is expressed in reciprocal seconds, sec^{-1} or in cycles/sec or in hertz (hz). Its symbol is ν.



The discovery of radio waves gave physicists the notion that there is a truly broad electromagnetic spectrum. When William Herschel measured the effect of the solar spectrum on a thermometer, he discovered that the mercury in a thermometer rose at a point somewhere below the red where the eye could see nothing. He called this part of the EM spectrum **infrared** (IR) waves. You cannot see infrared waves, but you can feel them. Infrared is often called heat. Infrared waves are very close to the red portion of the electromagnetic spectrum; in fact, we associate infrared waves (heat) with the color red. Put your hand over the element on an electric stove just after you have turned it on. You see nothing, but you feel the infrared waves. After a while you