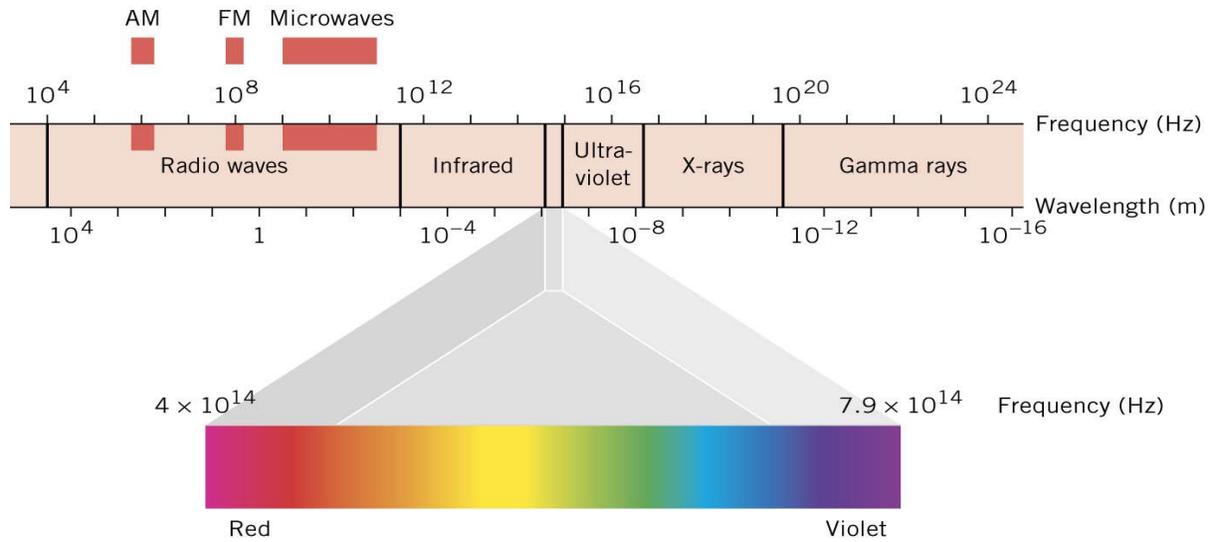


**The EM Spectrum**



For EM waves in \_\_\_\_\_  $v = c =$  \_\_\_\_\_  $m/s$

- This is \_\_\_\_\_ and is used to define the \_\_\_\_\_
- As EM waves travel \_\_\_\_\_ other substances, like plastic, it travels \_\_\_\_\_.

Remember \_\_\_\_\_ for all waves

An EM wave has a frequency of 90.7 MHz. What is the wavelength of this wave? What type of EM wave is it?

Wave's \_\_\_\_\_ is proportional to the \_\_\_\_\_ squared

- Wave's \_\_\_\_\_

$$I_{ave} = \frac{c\epsilon_0 E_0^2}{2} = \frac{cB_0^2}{2\mu_0} = \frac{E_0 B_0}{2\mu_0}$$

$$I_0 = 2I_{ave} \text{ and } I_{ave} = \frac{P}{A}$$

- Remember  $\epsilon_0 = 8.85 \times 10^{-12} \frac{C}{Vm}$  and  $\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$

A certain microwave oven can produce 1500 W of microwave radiation over an area that is 30 cm by 30 cm. What is the intensity in  $W/m^2$ ?

Calculate the peak electric field strength,  $E_0$ , in these waves.

What is the peak magnetic field strength,  $B_0$ ?

### Homework

- Why don't buildings block radio waves as completely as they do visible light?
- Give an example of energy carried by an electromagnetic wave.
- (a) Two microwave frequencies are authorized for use in microwave ovens: 900 and 2560 MHz. Calculate the wavelength of each. (b) Which frequency would produce smaller hot spots in foods due to interference effects? (OpenStax 24.6) **11.7 cm**
- A radio station utilizes frequencies between commercial AM and FM. What is the frequency of a 11.12-m-wavelength channel? (OpenStax 24.8) **26.96 MHz**
- Combing your hair leads to excess electrons on the comb. How fast would you have to move the comb up and down to produce red light? (OpenStax 24.10)  **$5.0 \times 10^{14}$  Hz**
- Some radar systems detect the size and shape of objects such as aircraft and geological terrain. Approximately what is the smallest observable detail utilizing 500-MHz radar? (OpenStax 24.14) **0.600 m**
- Determine the amount of time it takes for X-rays of frequency  $3 \times 10^{18}$  Hz to travel (a) 1 mm and (b) 1 cm. (OpenStax 24.15)  **$3.3 \times 10^{-12}$  s,  $3.3 \times 10^{-11}$  s**
- If you wish to detect details of the size of atoms (about  $1 \times 10^{-10}$  m) with electromagnetic radiation, it must have a wavelength of about this size. (a) What is its frequency? (b) What type of electromagnetic radiation might this be? (OpenStax 24.16)  **$3 \times 10^{18}$  Hz, X-rays**
- If the Sun suddenly turned off, we would not know it until its light stopped coming. How long would that be, given that the Sun is  $1.50 \times 10^{11}$  m away? (OpenStax 24.17) **500 s**
- Conversations with astronauts on lunar walks had an echo that was used to estimate the distance to the Moon. The sound spoken by the person on Earth was transformed into a radio signal sent to the Moon, and transformed back into sound on a speaker inside the astronaut's space suit. This sound was picked up by the microphone in the space suit (intended for the astronaut's voice) and sent back to Earth as a radio echo of sorts. If the round-trip time was 2.60 s, what was the approximate distance to the Moon, neglecting any delays in the electronics? (OpenStax 24.25)  **$3.90 \times 10^8$  m**
- Lunar astronauts placed a reflector on the Moon's surface, off which a laser beam is periodically reflected. The distance to the Moon is calculated from the round-trip time. (a) To what accuracy in meters can the distance to the Moon be determined, if this time can be measured to 0.100 ns? (b) What percent accuracy is this, given the average distance to the Moon is  $3.84 \times 10^8$  m? (OpenStax 24.26)  **$1.50 \times 10^{-2}$  m,  $3.91 \times 10^{-9}$  %**
- What is the intensity of an electromagnetic wave with a peak electric field strength of 125 V/m? (OpenStax 24.30) **20.7 W/m<sup>2</sup>**
- Assume the helium-neon lasers commonly used in student physics laboratories have power outputs of 0.250 mW. (a) If such a laser beam is projected onto a circular spot 1.00 mm in diameter, what is its intensity? (b) Find the peak magnetic field strength. (c) Find the peak electric field strength. (OpenStax 24.32) **318 W/m<sup>2</sup>,  $1.63 \times 10^{-6}$  T, 490 V/m**
- An AM radio transmitter broadcasts 50.0 kW of power uniformly in all directions. (a) Assuming all of the radio waves that strike the ground are completely absorbed, and that there is no absorption by the atmosphere or other objects, what is the intensity 30.0 km away? (Hint: Half the power will be spread over the area of a hemisphere.) (b) What is the maximum electric field strength at this distance? (OpenStax 24.33)  **$4.42 \times 10^{-6}$  W/m<sup>2</sup>,  $5.77 \times 10^{-2}$  V/m**
- A 2.50-m-diameter university communications satellite dish receives TV signals that have a maximum electric field strength (for one channel) of  $7.50 \mu\text{V/m}$ . (a) What is the intensity of this wave? (b) What is the power received by the antenna? (c) If the orbiting satellite broadcasts uniformly over an area of  $1.50 \times 10^{13}$  m<sup>2</sup> (a large fraction of North America), how much power does it radiate? (OpenStax 24.35)  **$7.47 \times 10^{-14}$  W/m<sup>2</sup>,  $3.67 \times 10^{-13}$  W, 1.12 W**