extension

Integrating Astronomy

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Keyword HF6LGTX

All electromagnetic waves move at the speed of light

All forms of electromagnetic radiation travel at a single high speed in a vacuum. Early experimental attempts to determine the speed of light failed because this speed is so great. As experimental techniques improved, especially during the nineteenth and early twentieth centuries, the speed of light was determined with increasing accuracy and precision. By the mid-twentieth century, the experimental error was less than 0.001 percent. The currently accepted value for light traveling in a vacuum is $2.997\,924\,58 \times 10^8$ m/s. Light travels slightly slower in air, with a speed of $2.997\,09 \times 10^8$ m/s. For calculations in this book, the value used for both situations will be 3.00×10^8 m/s.

The relationship between frequency, wavelength, and speed described in the chapter on vibrations and waves also holds true for light waves.

WAVE SPEED EQUATION

$$c = f\lambda$$

speed of light = frequency × wavelength

SAMPLE PROBLEM A

Electromagnetic Waves

PROBLEM

The AM radio band extends from 5.4×10^5 Hz to 1.7×10^6 Hz. What are the longest and shortest wavelengths in this frequency range?

SOLUTION

Given: $f_1 = 5.4 \times 10^5$ Hz $\quad f_2 = 1.7 \times 10^6$ Hz $\quad c = 3.00 \times 10^8$ m/s

Unknown: $\lambda_1 = ?\quad \lambda_2 = ?$

Use the wave speed equation on this page to find the wavelengths:

$$c = f\lambda \qquad \lambda = \frac{c}{f}$$

$$\lambda_1 = \frac{3.00 \times 10^8 \text{ m/s}}{5.4 \times 10^5 \text{ Hz}}$$

$$\boxed{\lambda_1 = 5.6 \times 10^2 \text{ m}}$$

$$\lambda_2 = \frac{3.00 \times 10^8 \text{ m/s}}{1.7 \times 10^6 \text{ Hz}}$$

$$\boxed{\lambda_2 = 1.8 \times 10^2 \text{ m}}$$

CALCULATOR SOLUTION

Although the calculator solutions are 555.5555556 m and 176.470588 m, both answers must be rounded to two digits because the frequencies have only two significant figures.