13 Reflection and Refraction

13-1 The Speed of Light

An important physical constant is the **speed of light**, *c*. In a vacuum, this speed is 3.00×10^8 m/s. All calculations in this book will use this value for the speed of light unless otherwise specified in the exercise.

Light has both wave and particle properties. The exercises in this chapter deal with the wave nature of light. For a wave of wavelength λ and frequency f traveling at the speed of light, c, $c = \lambda f$. The distance that light travels in a given amount of time can be represented by the equation $\Delta d = c\Delta t$.

Note that these two equations are both special cases of the more general equations, $v = \lambda f$ and $\Delta d = v\Delta t$.

Solved Examples

Example 1: How long does it take for light from the sun to reach Earth if the sun is 1.50×10^{11} m away?

Given: $\Delta d = 1.50 \times 10^{11}$ m
$c = 3.00 \times 10^8$ m/s

Unknown: $\Delta t = ?$
Original equation: $\Delta d = c\Delta t$

Solve: $$\Delta t = \frac{\Delta d}{c} = \frac{1.50 \times 10^{11}\ \text{m}}{3.00 \times 10^8\ \text{m/s}} = \mathbf{500.\ s}$$

This is a little more than 8 min.

Example 2: Microwave ovens emit waves of about 2450 MHz. What is the wavelength of this light?

Solution: The term MHz stands for Megahertz or 10^6 Hz. Therefore, the microwaves have a frequency of 2450×10^6 Hz.

Given: $c = 3.00 \times 10^8$ m/s
$f = 2450 \times 10^6$ Hz

Unknown: $\lambda = ?$
Original equation: $c = \lambda f$

Solve: $$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{2450 \times 10^6\ \text{Hz}} = \mathbf{0.122\ m}$$

Practice Exercises

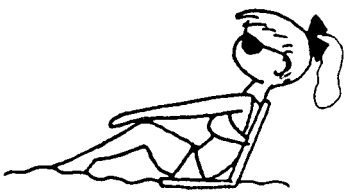
Exercise 1: When you look at a distant star or planet, you are looking back in time. How far back in time are you looking when you observe Pluto through the telescope from a distance of 5.91×10^{12} m?

Answer: _____

Exercise 2: If a person could travel at the speed of light, it would still take 4.3 years to reach the nearest star, Proxima Centauri. How far away, in meters, is Proxima Centauri? (Ignore any relativistic effects.)

Answer: _____

Exercise 3: When you go out in the sun, it is the ultraviolet light that gives you your tan. The pigment in your skin called *melanin* is activated by the enzyme *tyrosinase,* which has been stimulated by ultraviolet light. What is the wavelength of this light if it has a frequency of 7.89×10^{14} Hz?



Answer: _____

Exercise 4: IRAS, the Infrared Astronomy Satellite launched by NASA in 1983, had a detector that was supercooled to enable it to measure infrared or heat radiation from different regions of space. What is the frequency of infrared light that has a wavelength of 1.00×10^{-6} m?

Answer: _____

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1. 19 700 s
3. 3.80×10^{-7} m