Problem 2.6

How many wavelengths of a green laser ($\lambda = 532$ nm) can fit into a distance equal to the thickness of a human hair (100 μm)? How far will the same number of waves extend if they originate from a microwave oven ($\nu = 2.45$ GHz)?

Solution

To find out how many wavelengths of a green laser can fit into the thickness of a human hair, divide the two lengths (both in meters).

$$\frac{100 \cancel{\mu\text{m}} \times \frac{1 \text{ m}}{1\times10^6 \cancel{\mu\text{m}}}}{532 \cancel{\text{nm}} \times \frac{1 \text{ m}}{1\times10^9 \cancel{\text{nm}}}} \approx 188$$

The frequency of the microwave oven is given, so the wavelength can be found using the fundamental relationship, $\lambda\nu = c$.

$$\lambda = \frac{c}{\nu} = \frac{299\,792\,458 \ \frac{\text{m}}{\text{s}}}{2.45 \cancel{\text{GHz}} \times \frac{1\times10^9 \text{ Hz}}{1 \cancel{\text{GHz}}}} \approx 0.122 \text{ m}$$

188 waves with this wavelength extends to a distance of

$$188 \times 0.122 \text{ m} \approx 23 \text{ m}.$$