Chapter 33 End-of-Chapter Problems

Halliday & Resnick, 10th Edition

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Hit me where it Matters

1 Problem 1

A certain helium-neon laser emits red light in a narrow band of wavelengths centered at 632.8 nm and with a "wavelength width" (such as on the scale of Fig. 33-1) of 0.0100 nm. What is the corresponding "frequency width" for the emission?

1.1 Solution

Use the traditional formula for the wavelength. Here, the speed of the wave is the speed of light. We can treat this like an error and raw value issue.

$$v = \lambda f \rightarrow f = \frac{c}{\lambda} \tag{1}$$

$$\frac{\delta f}{f} = \frac{\delta \lambda}{\lambda} \tag{2}$$

$$\delta f = f * \frac{\delta \lambda}{\lambda} = c * \frac{\delta \lambda}{\lambda^2} \tag{3}$$

$$= 2.998 \times 10^8\,\mathrm{m/s} * \frac{0.0100\,\mathrm{nm}}{(632.8\,\mathrm{nm})^2} \tag{4}$$

$$= \boxed{7.49\,\mathrm{GHz}} \tag{5}$$

2 Problem 5

What inductance must be connected to a 17 pF capacitor in an oscillator capable of generating 550 nm (i.e., visible) electromagnetic waves? Comment on your answer.

2.1 Solution

For an LC circuit, the angular frequency is $\frac{1}{\sqrt{LC}}$.

$$\omega = \frac{1}{\sqrt{LC}} \tag{6}$$

The linear frequency is calculatable from this.

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi\sqrt{LC}} \tag{7}$$

This can be relatable to the wave speed (the speed of light in the case of an EM wave).

$$v = \lambda f \tag{8}$$

$$c = \lambda f = \frac{\lambda}{2\pi\sqrt{LC}} \tag{9}$$

Ths can be solved for the inductance (L) and found a solution for.

$$c = \frac{\lambda}{2\pi\sqrt{L}\sqrt{C}} \tag{10}$$

$$\sqrt{L} = \frac{\lambda}{2\pi c\sqrt{C}} \tag{11}$$

$$L = \frac{\lambda^2}{(2\pi)^2 c^2 C} \tag{12}$$

$$= \frac{(550\,\text{nm})^2}{4\pi^2(2.998\times10^8\,\text{m/s})^2 * 17\,\text{pF}} \tag{13}$$

$$= \boxed{5.015\times10^{-21}\,\text{H}} \tag{14}$$

3 Problem 7

What is the intensity of a traveling plane electromagnetic wave if B_m is $1.0 \times 10^{-4}\,\mathrm{T}$?

3.1 Solution

Start by calculating the electric wave magnitude.

$$c = \frac{E_m}{B_m} \tag{15}$$

$$E_m = c\,B_m = 2.998 \times 10^{8}\,\mathrm{m/s} * 1.0 \times 10^{-4}\,\mathrm{T} = 2.998 \times 10^{4}\,\mathrm{N/C} \tag{16}$$

The intensity can be calculated from this. Bear in mind that $E_{\mathrm{rms}} = \frac{E_m}{\sqrt{2}}$.

$$I = \frac{1}{c\mu_0} E_{\mathrm{rms}}^2 = \frac{E_m^2}{2c\mu_0} = \frac{cB_m^2}{2\mu_0} \tag{17}$$

$$= \frac{2.998 \times 10^{8}\,\mathrm{m/s} * 10^{-8}\,\mathrm{T}^2}{2 * 1.257 \times 10^{-6}\,\mathrm{H/m}} \tag{18}$$

$$= \boxed{1.193 \times 10^{6}\,\mathrm{W/m}} \tag{19}$$

4 Problem 9

Some neodymium-glass lasers can provide 100 TW of power in 1.0 ns pulses at a wavelength of 0.26 µm. How much energy is contained in a single pulse?

4.1 Solution

5 Problem 11

A plane electromagnetic wave traveling in the positive direction of an x axis in vacuum has components $E_x = E_y = 0$ and E_z has the below value.

$$E_z = (2.0\,\mathrm{V/m})\cos\left[(\pi \times 10^{15}\,\mathrm{s}^{-1})(t - x/c)\right] \tag{20}$$

(a) What is the amplitude of the magnetic field component? (b) Parallel to which axis does the magnetic field oscillate? (c) When the electric field component is in the positive direction of the z axis at a certain point P, what is the direction of the magnetic field component there?

5.1 Solution

6 Problem 13

6.1 Solution

7 Problem 19

7.1 Solution

8 Problem 21

8.1 Solution

9 Problem 29

9.1 Solution

10 Problem 33

10.1 Solution

11 Problem 37

11.1 Solution

12 Problem 41

12.1 Solution

13 Problem 43

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14 Problem 45

14.1 Solution

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15.1 Solution

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