Chapter 24

Problems & Exercises

3.

150 kV/m

6.

(a) 33.3 cm (900 MHz) 11.7 cm (2560 MHz)

(b) The microwave oven with the smaller wavelength would produce smaller hot spots in foods, corresponding to the one with the frequency 2560 MHz.

8.

26.96 MHz

10.

5.0×10^{14} Hz

12.

$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{1.20 \times 10^{15}\ \text{Hz}} = 2.50 \times 10^{-7}\ \text{m}$

14.

0.600 m

16.

(a) $f = \frac{c}{\lambda} = \frac{3.00 \times 10^8\ \text{m/s}}{1 \times 10^{-10}\ \text{m}} = 3 \times 10^{18}$ Hz

(b) X-rays

19.

(a) 6.00×10^6 m

(b) 4.33×10^{-5} T

21.

(a) 1.50×10^{6} Hz, AM band
(b) The resonance of currents on an antenna that is 1/4 their wavelength is analogous to the fundamental resonant mode of an air column closed at one end, since the tube also has a length equal to 1/4 the wavelength of the fundamental oscillation.

23.

(a) 1.55×10^{15} Hz

(b) The shortest wavelength of visible light is 380 nm, so that

$\frac{\lambda_{\text{visible}}}{\lambda_{\text{UV}}}$
$= \frac{380 \text{ nm}}{193 \text{ nm}}$
$= 1.97.$

In other words, the UV radiation is 97% more accurate than the shortest wavelength of visible light, or almost twice as accurate!

25.

3.90×10^8 m

27.

(a) 1.50×10^{11} m

(b) 0.500 μs

(c) 66.7 ns

29.

(a) -3.5×10^2 W/m^2

(b) 88%

(c) 1.7 μT

30.

$$\begin{aligned} I &= \frac{c\varepsilon_0 E_0^2}{2} \\ &= \frac{\left(3.00\times10^8 \text{ m/s}\right)\left(8.85\times10^{-12}\text{C}^2/\text{N}\cdot\text{m}^2\right)\left(125 \text{ V/m}\right)^2}{2} \\ &= \mathbf{20.7 \text{ W/m}^2} \end{aligned}$$

32.

(a) $I = \frac{P}{A} = \frac{P}{\pi r^2} = \frac{0.250\times10^{-3} \text{ W}}{\pi\left(0.500\times10^{-3} \text{ m}\right)^2} = 318 \text{ W/m}^2$

$$\begin{aligned} I_{\text{ave}} &= \frac{\text{cB}_0^2}{2\mu_0} \Rightarrow B_0 = \left(\frac{2\mu_0 I}{c}\right)^{1/2} \\ &= \left(\frac{2\left(4\pi\times10^{-7} \text{ T}\cdot\text{m/A}\right)\left(318.3 \text{ W/m}^2\right)}{3.00\times10^8 \text{ m/s}}\right)^{1/2} \end{aligned}$$

(b) $$= \mathbf{1.63\times10^{-6} \text{ T}}$$

$$E_0 = \text{cB}_0 = \left(3.00\times10^8 \text{ m/s}\right)\left(1.633\times10^{-6} \text{ T}\right)$$

(c) $$= \mathbf{4.90\times10^2 \text{ V/m}}$$

34.

(a) 89.2 cm

(b) 27.4 V/m

36.

(a) 333 T

(b) 1.33×10^{19} W/m^2

(c) 13.3 kJ

38.

(a) $I = \frac{P}{A} = \frac{P}{4\pi r^2} \propto \frac{1}{r^2}$

(b) $I \propto E_0^2, B_0^2 \Rightarrow E_0^2, B_0^2 \propto \frac{1}{r^2} \Rightarrow E_0,\ B_0 \propto \frac{1}{r}$

40.

13.5 pF

42.

(a) 4.07 kW/m^2

(b) 1.75 kV/m

(c) 5.84 μT

(d) 2 min 19 s

44.

(a) 5.00×10^3 W/m^2

(b) 3.88×10^{-6} N

(c) 5.18×10^{-12} N

46.

(a) $t = 0$

(b) 7.50×10^{-10} s

(c) 1.00×10^{-9} s

48.

(a) 1.01×10^6 W/m^2

(b) Much too great for an oven.

(c) The assumed magnetic field is unreasonably large.

50.

(a) 2.53×10^{-20} H

(b) L is much too small.

(c) The wavelength is unreasonably small.

53.

$$B = \frac{E}{c}$$

(a) $B = \frac{1250}{3.00\times10^8}\,\mathrm{T} = 4.17\times10^{-6}\ \mathrm{T}$

(b) E would increase.

(c) It would be by $1/c$.