1. PSEC 34.P.037 [317859] In SI units, the electric field in an electromagnetic wave is described by the following equation.

\[ E_y = 118 \sin(1.20 \times 10^7 x - \omega t) \]

(a) Find the amplitude of the corresponding magnetic field oscillations.
\[ 0.393 \, \mu T \]
(b) Find the wavelength \( \lambda \).
\[ 0.523 \, \mu m \]
(c) Find the frequency \( f \).
\[ 5.7 \times 10^{14} \, Hz \]

\[ E_0 = 118 \, V/m \quad B_0 = B_0 \sin(1.20 \times 10^7 x - \omega t) \]

\[ B_0 = \frac{E_0}{\varepsilon_0} = \frac{118}{3 \times 10^{-8}} = 3.93 \times 10^{-7} \, T \]

\[ \frac{2\pi}{\lambda} = 1.20 \times 10^{-7} \]
\[ \lambda = \frac{2\pi}{1.2} \times 10^{-7} = 5.23 \times 10^{-7} \, m \]

\[ \lambda f = \frac{c}{\omega} = \frac{3.0 \times 10^8}{5.23 \times 10^{-7}} = 5.7 \times 10^{14} \]

2. PSEC 34.P.014 [317992] A monochromatic light source emits 135 W of electromagnetic power uniformly in all directions.

(a) Calculate the average electric-field energy density 3.00 m from the source.
\[ 6 \text{ nJ/m}^3 \]
(b) Calculate the average magnetic-field energy density at the same distance from the source.
\[ 2 \text{ nJ/m}^3 \]
(c) Find the wave intensity at this location.
\[ 1.2 \text{ W/m}^2 \]

\[ \mathcal{U} = \varepsilon_0 E^2 \quad \mathcal{S} = \varepsilon_0 E^2 \lambda \]

\[ 4\pi \cdot R^2 \cdot S = 135 \]
\[ S = \frac{135}{4\pi \cdot R^2} \quad \text{So,} \quad \varepsilon_0 E^2 = \frac{135}{4\pi \cdot c^2} \]

\[ \mathcal{U} = \frac{\varepsilon_0 E^2}{2} = 2 \text{ nJ/m}^3 \]

\[ V_B = \frac{\mathcal{U}}{2} = 2 \text{ nJ/m}^2 \]

\[ \mathcal{S} = \mathcal{U} \cdot \lambda = 3 \times 10^8 \times 0.4 \times 10^{-8} = 1.2 \text{ W/m}^2 \]
3. PSEB 34.P.024 [317923] A 20.0 mW laser has a beam diameter of 1.30 mm.

(a) What is the intensity of the light, assuming it is uniform across the circular beam?

\[
I = \frac{15}{\pi (0.0013)^2} = 15 \text{ kW/m}^2
\]

(b) What is the average energy density of the beam?

\[
U = \frac{I}{c} = \frac{15 \times 10^3}{3.0 \times 10^8} = 5 \times 10^{-5} \text{ J/m}^3 = 50 \text{ \mu J/m}^3
\]

4. PSEB 34.P.027 [317963] A radio wave transmits 27.0 W/m² of power per unit area. A flat surface of area A is perpendicular to the direction of propagation of the wave. Calculate the radiation pressure on it, assuming the surface is a perfect absorber.

\[
P = \frac{S}{c} = \frac{27.0}{3.0 \times 10^8} = 9 \times 10^{-8} \text{ Pa}
\]

\[
P = 90 \text{ nPa}
\]
5. A 15.0 mW helium-neon laser (\(\lambda = 632.8\) nm) emits a beam of circular cross-section with a diameter of 1.90 mm.

   (a) Find the maximum electric field in the beam.
   \[
   E = \frac{2}{\pi} \frac{P}{A} \approx 2 \frac{\text{kN/m}}{\text{C}}
   \]

   (b) What total energy is contained in a 1.00 m length of the beam?
   \[
   E = \frac{50}{\text{pJ}}
   \]

   (c) Find the momentum carried by a 1.00 m length of the beam.
   \[
   p = 1.67 \times 10^{-19} \text{ kg} \cdot \text{m/s}
   \]

6. What are the wavelengths of electromagnetic wave in free space that have the following frequencies?

   (a) 9.00 \times 10^{18} \text{ Hz}
   \[
   \lambda = \frac{c}{f} = \frac{3.0 \times 10^8}{9.0 \times 10^{19}} = 3.3 \text{ pm}
   \]

   (b) 8.00 \times 10^9 \text{ Hz}
   \[
   \lambda = \frac{c}{f} = \frac{3.0 \times 10^8}{8 \times 10^9} = 3.75 \text{ cm}
   \]