Introduction to Lasers

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Home problems for the course

Instructor: Prof. ***Alex Kaplan***, ECE, Barton Hall, #304
email: alexander.kaplan@jhu.edu; web: http://psi.ece.jhu.edu/~kaplan

1.***Introduction*** : Solutions

1.1. What is the frequency (in Hz) and energy (in eV) of a photon with wavelength 1 m? 1 cm, 1 μm, 1 nm?

Solution: Recall that $E \times \lambda \approx 1.24 \times 10^{-4}\ eV \times cm$; hence $E \approx 1.24 \times 10^{-4} eV/\lambda(cm)$. Frequency, $\nu = c/\lambda = E/h$.

For $\lambda = 1m$, $E = 1.24 \times 10^{-6} eV$, $\nu = 3 \times 10^{8}\ Hz$

for $\lambda = 1cm$, $E = 1.24 \times 10^{-4} eV$, $\nu = 3 \times 10^{10}\ Hz$

for $\lambda = 1\mu m$, $E = 1.24\ eV$, $\nu = 3 \times 10^{14}\ Hz$

for $\lambda = 1nm$, $E = 1.24 \times 10^{3}\ eV$, $\nu = 3 \times 10^{17}\ Hz$

1.2. What is the refractive index of (a) an air, (b) regular glass, (c) diamond?

Rough data for $\lambda \sim 0.59\mu m$: air -- $n \approx 1 + 3 \times 10^{-4}$; regular glass -- $n \sim 1.516$; diamond -- $n \approx 2.42$.

1.3. What is the reflectivity (i. e. ratio of an incident to a reflected intensity of light) of a surface air/glass under normal incidence in optical domain?

Solution: reflectivity (i. e. ratio of ***intensities*** of the reflected and incident light) is $R = (n_2 - n_1)^2/(n_2 + n_1)^2$. Thus, for air-glass surface it is $R \approx 0.04$

1.4. In a plane EM-wave in vacuum, what is the ratio of electrical and magnetic energy density?

Answer: these two energies are equal.