PH-1020
Problem Set - 7
Department of Physics, IIT Madras
Magnetic Fields in Matter
March-June 2023 Semester

Notation:

- Notation throughout follows that of Griffiths, Electrodynamics.
- Bold face characters, such as $\boldsymbol{v}$, represent three-vectors.

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1. Write the real component of electric and magnetic fields for a monochromatic plane wave (Amplitude = E_0, frequency = ω and phase angle $\delta = 0$) which is
   (a) travelling in the negative x-direction and polarized in the z-direction.
   (b) travelling along (1,1,1) with polarization parallel to the xz-plane.
2. Consider a linearly polarized plane EM waves propagating in z-directions, with their plane of polarization along the x direction. The electric field's amplitude is given by $|E_0|$, the frequency of the wave is ω, and its wave number is k. Find the value of
$$\frac{\partial U}{\partial t} + \boldsymbol{\nabla}.\boldsymbol{S} \ ,$$
where U is the energy density and $\boldsymbol{S}$ is the Poynting vector.
3. The intensity of sunlight hitting the earth is about 1300 W/m^2. If sunlight strikes a perfect absorber, what pressure does it exert? How about a perfect reflector? What fraction of atmospheric pressure does this amount to?
4. A He-Ne laser emits a plane wave which is polarized along $\hat{\boldsymbol{x}}$ and propagating in yz-plane at an angle $\pi/3$ to the y-axis in a medium of refractive index 1.5. The wavelength and intensity of the plane wave are 633 nm and 1 W/m^2, respectively. Calculate the electric and magnetic field associated with the plane waves.
5. Considering an EM wave, traveling in the air, with amplitude 5 V/m and polarized along $\hat{\boldsymbol{y}}$, incident normally on a dielectric of refractive index 2.5.The free space wavelength is 6×10^{-7} m
   (a) Find the reflecting and transmitting waves (i.e., express E_R, H_R, E_T, H_T).
   (b) Calculate the Poynting vectors associated with the incident, reflected, and transmitted wave and show that $R + T = 1$.
6. The refractive index of diamond is 2.42. Plot the graph of $\frac{E_{0T}}{E_{0I}}$ vs θ_I and $\frac{E_{0R}}{E_{0I}}$ vs θ_I for the air/diamond interface. Here, θ_I is the angle of incidence and consider $\mu_1 = \mu_2 = \mu_0$. Also, calculate
   (a) the amplitude of normal incidence,
   (b) Brewster's Angle, and
   (c) the angle at which the reflected and transmitted amplitudes are equal.