HW3 PHYS168 lasers Spring 2012 Prepared by N. Eradat Due date Feb 27, 2012

- V1.4, 1.7, 1.8, 1.10, 2.1, 2.3, 2,5, 2.6
- Problems from review

1 a) Prove that for a harmonic plane electromagnetic wave $\mathbf{E} = \mathbf{E}_0 \cos(\mathbf{k}\cdot\mathbf{r} - \omega t)$, traveling through an insulating isotropic medium, $|\mathbf{E}| = V|\mathbf{B}|$ and in vacuum $|\mathbf{E}| = c|\mathbf{B}|$.

b) Calculate the magnitude of the poynting vector

c) Prove that the energy content of this plane wave, in unit volume, due to electric and magnetic fields is equal.

d) Calculate the total energy per unit volume.

2 a) Calculate time average of the harmonic plane wave $E = E_0 e^{i(kx-\omega t)}$ over a time of T (T is not temporal period of the wave).

b) Calculate the $\langle \cos(kx-\omega t)\rangle_T$, $\langle \sin(kx-\omega t)\rangle_T$, $\langle \cos(kx-\omega t)\rangle_T^2$, $\langle \sin(kx-\omega t)\rangle_T^2$. Use the notation $\sin c\, x = \dfrac{\sin x}{x}$.

c) Use the results of parts a and b to show that for plane waves in vacuum $I \equiv \langle \mathbf{S}\rangle_T = \dfrac{c\varepsilon_0}{2} E_0^2$

d) Calculate the optical flux density for the plane EM wave with the following electrical (also called optical) field moving in vacuum

$$E_x = E_y = 0,\ E_z = 100\sin\left[8\pi\times 10^{14}\left(t - \frac{x}{3\times 10^8}\right)\right].\ (Ans:\ 13.3\ W/m^3)$$