PHYS302 Fall 2023

Homework 8

7.39* An ionized gas or plasma is a dispersive medium for EM waves. Given that the dispersion equation is

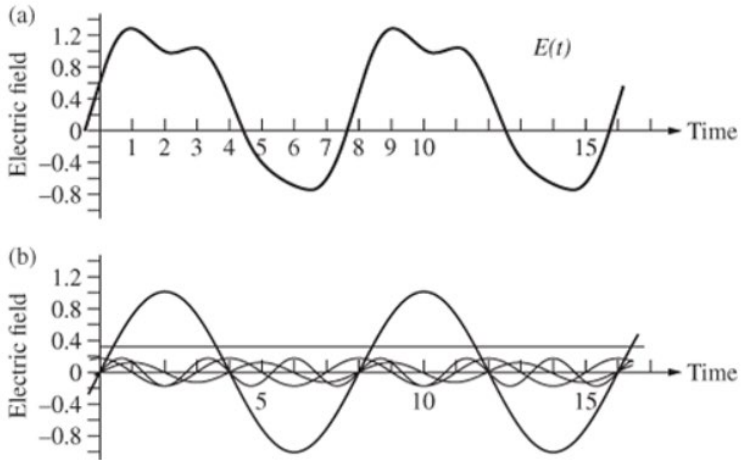
$$\omega^2 = \omega_p^2 + c^2 k^2$$

where ω_p is the constant plasma frequency, determine expressions for both the phase and group velocities and show that $v v_g = c^2$.

7.42* **Figure P.7.42** depicts an electric field in time and the Fourier components that compose it. The units are arbitrary. Given that

$E(t) = \frac{1}{3} + \sin\omega t + \frac{1}{6}\cos 2\omega t + \frac{1}{8}\sin 2\omega t + \frac{1}{6}\sin 3\omega t$(a) Explain why the series contains both sine and cosine terms. (b) Why does the series contain harmonic terms having arguments with odd and even multiples of ωt? (c) What is the value of the *DC* term? (d) What is the value of A_0? (e) What is the value of the period of $E(t)$? (f) Make a sketch of the frequency spectrum, including the $\omega = 0$ term.

Figure P.7.42



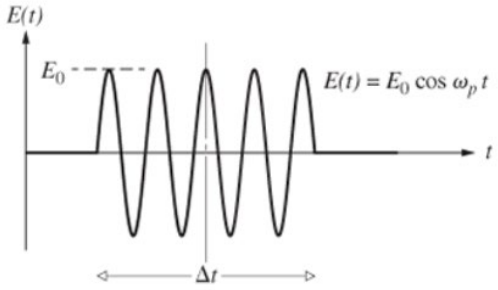
7.51* Consider the periodic function

$$E(t) = E_0 \cos \omega t$$

and suppose all of the negative half-cycles are removed. Determine the Fourier series representation of the resulting modified ("rectified") function.

7.54 Write an expression for the transform $A(\omega)$ of the harmonic pulse of **Fig. P.7.54**. Check that sinc u is 50% or greater for values of *u roughly* less than $\pi/2$. With that in mind, show that $\Delta v\ \Delta t \approx 1$, where Δv is the bandwidth of the transform at half its maximum amplitude. Verify that $\Delta v\ \Delta t \approx 1$ at half the maximum value of the power spectrum as well. The purpose here is to get some sense of the kind of approximations used in the discussion.

Figure P.7.54



7.56* A blue-light LED with a mean vacuum wavelength of 446 nm has a linewidth of 21 nm. Determine its coherence time and coherence length.

7.59* A magnetic-field technique for stabilizing a He–Ne laser to 2 parts in 10^{10} has been patented. At 632.8 nm, what would be the coherence length of a laser with such a frequency stability?

8.2* Two waves $E_z = 4 \sin(ky - \omega t)$ and $E_x = 3 \sin(ky - \omega t)$, both in SI units, overlap in space. Describe completely the state of polarization of the resultant.

8.3* Consider the following two waves expressed in SI units: $E_x = 8 \sin(ky - \omega t + \pi/2)$ and $E_z = 8 \sin(ky - \omega t)$. Which wave leads, and by how much? Describe the resultant wave. What is the value of its amplitude?

Extra credit:

Very narrow linewidth lasers have very long coherence times. Search the internet for such a laser. Cite your source, report the linewidth, and calculate the coherence time.

These lasers are very important to optical clock operation. Why do you think that is? You may want to read up on what an optical clock is.