

Homework # 5
due Wednesday Oct 27 at 5PM

Reading: Hecht 4.1-4.2,7.1-7.2

Problems:

1. (Hecht 4.4) The equation for a driven damped oscillator is

$$m_e \ddot{x} + m_e \gamma \dot{x} + m_e \omega_0^2 x = q_e E(t)$$

(a) Explain the significance of each term.

(b) Let $E = E_0 e^{i\omega t}$ and $x = x_0 e^{i(\omega t - \alpha)}$, where E_0 and x_0 are real quantities. Substitute into the above expression and show that $x_0 = \frac{q_e E_0}{m_e} \frac{1}{[(\omega_0^2 - \omega^2)^2 + \gamma^2 \omega^2]^{1/2}}$

(c) Derive an expression for the phase lag, α , and discuss how α varies as ω goes from $\omega \ll \omega_0$ to $\omega = \omega_0$ to $\omega \gg \omega_0$.

2. (Hecht 3.49) In the next chapter, Eq. (4.47), we'll see that a substance reflects radiant energy appreciably when its index differs most from the medium in which it is embedded.

(a) The dielectric constant of ice measured at microwave frequencies is roughly 1, whereas for water is about 80 times greater – why?

(b) How is it that a radar beam easily passes through ice but is considerably reflected when encountering a dense rain?

3. Plot and write the equation of the superposition of the following harmonic waves:

$E_1 = \sin(\frac{\pi}{18} - \omega t)$, $E_2 = 3 \cos(\frac{5\pi}{9} - \omega t)$, and $E_3 = 2 \sin(\frac{\pi}{6} - \omega t)$ where the period of each is 2s. What is the frequency of the resulting superposition? Please use a graphing program, preferably Mathematica or another software of your choice.

4. Show that when two waves of Eq. (7.5) are in-phase, the resulting amplitude squared is a maximum equal to $(E_{01} + E_{02})^2$ and when they are out-of-phase it is a minimum equal to $(E_{01} - E_{02})^2$.

5. (Hecht 7.15) Imagine that we strike two tuning forks, one with a frequency of 340 Hz, the other 342 Hz. What will we hear?