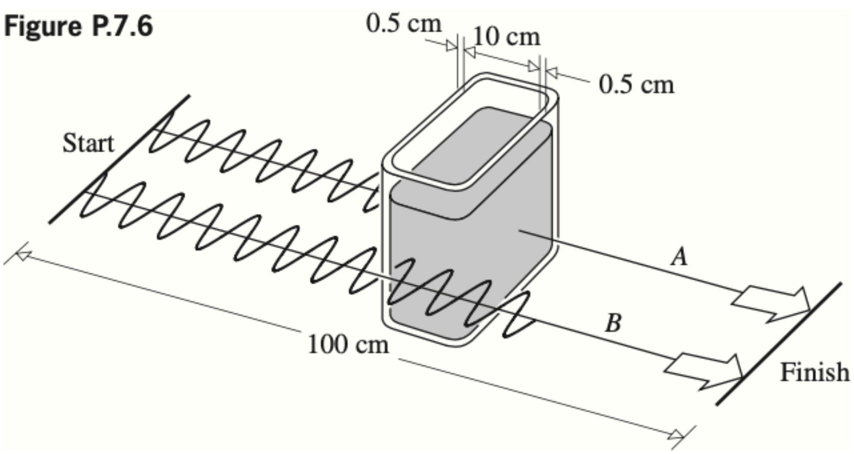
PH481 Homework 4

Due: Monday, 6th of February 2023

7.4* Show that the *optical path length*, defined as the sum of the products of the various indices times the thicknesses of media traversed by a beam, that is, $\sum_i n_i x_i$, is equivalent to the length of the path in vacuum that would take the same time for that beam to negotiate.

7.6* Determine the optical path difference for the two waves A and B, both having vacuum wavelengths of 500 nm, depicted in Fig. P.7.6; the glass ($n = 1.52$) tank is filled with water ($n = 1.33$). If the waves start out in-phase and all the above numbers are exact, find their relative phase difference at the finishing line.

Figure P.7.6



7.7* Using Eqs. (7.9), (7.10), and (7.11), show that the resultant of the two waves

$$E_1 = E_{01} \sin[\omega t - k(x + \Delta x)]$$

and

$$E_2 = E_{01} \sin(\omega t - kx)$$

is

$$E = 2E_{01} \cos\left(\frac{k\,\Delta x}{2}\right) \sin\left[\omega t - k\left(x + \frac{\Delta x}{2}\right)\right] \qquad [7.17]$$

You could also do this problem using the complex exponential forms of the waves. That is, let

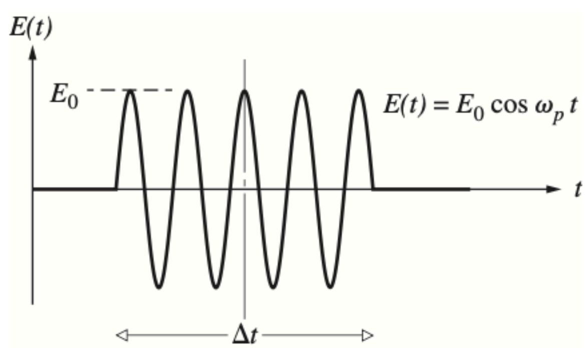
$$E_1 = E_{01} e^{i[\omega t - k(x+\Delta x)]}$$

$$E_2 = E_{02} e^{i[\omega t - kx]}$$

and then use the imaginary part to get the sine functions as needed.

7.54 Write an expression for the transform *A(ω)* 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 $\Delta\nu\,\Delta t \approx 1$, where $\Delta\nu$ is the bandwidth of the transform at half its maximum amplitude. Verify that $\Delta\nu\,\Delta t \approx 1$ 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



7.63* Suppose we spread white light out into a fan of wavelengths by means of a diffraction grating and then pass a small select region of that spectrum out through a slit. Because of the width of the slit, a band of wavelengths 1.2 nm wide centered on 500 nm emerges. Determine the frequency bandwidth and the coherence length of this light.