Physics 380H - Wave Theory **Homework #03**

Fall 2004 Due 12:01 PM, Monday 2004/10/04

[50 points total]

"Journal" questions:
– Considering your entire history as a student, what course (in any subject) has been the most rewarding for you? Why?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. (From Towne P2-6. pg 36) Show from the basic equations of the acoustic approximation that p, s, ξ, and $\dot{\xi}$ all satisfy the one-dimensional wave equation. [10]

2. (From Towne P2-10. pg 36) Consider a progressive sinusoidal plane wave of given frequency ω and displacement amplitude ξ_m travelling in air, and a wave having the same values of ω and ξ_m traveling in water. How do the pressure amplitudes compare? If the value of s_m for the wave in water is sufficiently small to satisfy the acoustic approximation, is it necessarily so for the wave in air?. [10]

3. (From Towne P2-20. pg 38) Determination of an acoustic wave from given initial conditions:
   (a) For plane waves satisfying the linearized one-dimensional wave equation in a uniform fluid medium of infinite extent, assume that the function $\dot{\xi}(x,0)$, which specifies the initial velocities of all the particles, and the initial pressure distribution, $p(x,0)$, are given. Find the general expression for $p(x,t)$. [10]
   (b) Apply your general result from part (a) to the special case of particles initially at rest,
   $$p(x,0) = \begin{cases} p_0, & x < 0, \\ 0, & x \geq 0. \end{cases}$$
   Plot or sketch the graph of $p(x,t)$ at some later time. (Such a situation would result if a long tube were divided in the middle by a membrane, the pressure on the two sides of the membrane being P_0 and P_0', and the membrane were ruptured at $t = 0$. For the linearized wave equation to apply, we must have $p_0 = P_0 - P_0' \ll P_0$.) [10]
   (c) Given that the initial pressure and velocity distributions satisfy the condition characteristic of a +wave, $p(x,0) = \rho_0 c\dot{\xi}(x,0)$, show that your general result from part (a) reduces to the pure +wave $p(x,t) = p(x-ct,0)$. [10]

Headstart for next week, Week 04, starting Monday 2004/10/04:
– Read Chapter 3 "Boundary value problems" in "Wave Phenomena" by Towne, omit 3-9
– – Section 3-4 "Reflection and transmission at an interface"
– – Section 3-5 "Reflection of a sinusoidal wave; partial standing wave"
– – Section 3-6 "Extreme mismatch of impedances; rigid and free surfaces"
– – Section 3-7 "Reflection of a sinusoidal wave from a pair of interfaces"
– – Section 3-8 "Reflection of a sinusoidal wave at a pair of interfaces, alternate method"
– Read Chapter 4 "Energy in a Sound Wave; Isomorphisms" in Towne, omit 4-7
– – Section 4-1 "Energy density and energy flux for a plane sound wave"
– – Section 4-2 "The law of conservation of energy"
– – Section 4-3 "Separability of energy into + and – components"
– – Section 4-4 "Convective and radiative energy terms"
– – Section 4-5 "Relative radiative intensities in reflection and transmission at a single interface"
– – Section 4-6 "Intensity relations for progressive sinusoidal waves"