GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Quarter 1995

Acoustics
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

-- Please sign your name on the back of this page --

G. W. Woodruff School of Mechanical Engineering

Acoustics Ph. D. Area Exam - Fall 1995

Instructions:

(1) Answer only three problems out of four.
(2) Place a mark in the space provided to indicate that you wish your solution to count. Failure to comply with this instruction will result in grading the first three problems.
(3) Exam is closed book, and no other reference mataerials are permitted.
(4) State all assumptions clearly.
(5) Be sure that all work is legible.

Grade? [Y/N]

Problem 1

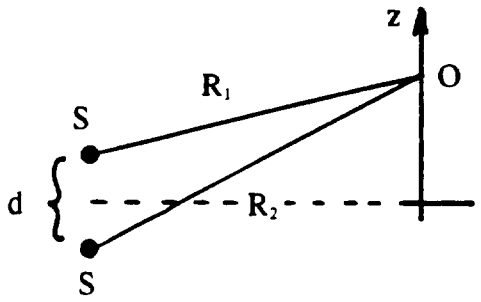
A small spherical source pulsates in water ($\rho = 1{,}000\ kg/m^3$, $c = 1{,}500\ m/s$) and generates at a distance $r = r_0 = 1\ m$ an acoustic pressure of the form $p(t) = A\ exp(-at)$ for $t > 0$ with $A = 1\ N/m^2$, and $a = 1\ s^{-1}$, and $p(t) = 0$ for $t < 0$. Find the radial particle velocity $v(R,t)$ that one would expect at a distance $R = 1.5\ km$ from the source. Sketch the time waveform $v(R,t)$ and comment your answer.

Problem 2

Grade? [Y/ N] _____

(a) Distinguish between coherent and incoherent acoustic sources. What is the definition of *a pair of mutually incoherent acoustic sources.*

(b) Two monopole acoustic sources of equal amplitude S are located in an unbounded fluid as shown in the figure. The separation d of the sources is on the order of several acoustic wavelengths λ. The sources radiate harmonically at the same frequency. Derive expressions for the *sound pressure level* at point O in the fluid when, (1) the sources are coherent, and (2) the sources are incoherent. Sketch the sound pressure level as a function of the distance z for each of the above cases.



Problem 3

Grade? [Y/N]

Find the lowest resonance frequency of the ear canal in the human ear. To do so, model the ear canal as a rigid pipe open at one end (the pinna) and terminated by a rigid wall at the other end (the ear drum). The length of the pipe is about 25 mm. The open end of the pipe is excited by a harmonic wave (particle velocity) of the form $v(0,t) = V_0 \cos(\omega t)$, where V_0 is a constant and ω is the angular frequency of the sound. Find an expression for the particle velocity, and one for the pressure inside the ear canal. Find the lowest resonance frequency of the ear canal.

Problem 4

Grade? [Y / N] ____

A stretched membrane separates two acoustic media having sound speeds $c_2 > c_1$ and densities $\rho_2 > \rho_1$. Let $w(x,y,t)$ denote the transverse displacement of the membrane pointing into medium 2. The corresponding equation of motion of the plate is

$$T\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}\right)-m\frac{\partial^2 w}{\partial t^2}=p_{s2}-p_{s1}$$

where p_{s1} and p_{s2} are the surface pressures in the respective media, T is the tension per unit length in the plate, and m is the mass per unit surface area in the plate.

A harmonic plane wave having amplitude P_1 propagates in medium 1 at angle of incidence θ_1 relative to the plate.

(a) Determine the largest value of θ_1 for which energy will propagate in the z direction in medium 2.

(b) Consider the situation where θ_1 is smaller than the value in part (a). Derive an expression for the amplitude of the signal transmitted into medium 2.

(c) Identify the combination of T and m that will maximize the signal transmitted into medium 2 when the frequency is specified. Does this parameter combination depend on the angle of incidence?