GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1997

Acoustics
EXAM AREA

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

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

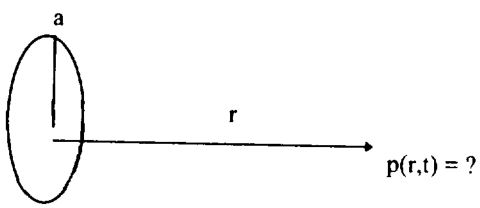
Please **print** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

Closed Books

Problem 1:

Derive an expression for the acoustic pressure, p(r,t), measured **ON AXIS** at a distance r in front of a circular piston of radius a in a rigid infinite baffle, when the piston velocity (normal component) is a transient v(t) which is uniform across the face of the piston. The medium is a fluid with density ρ and sound speed c.

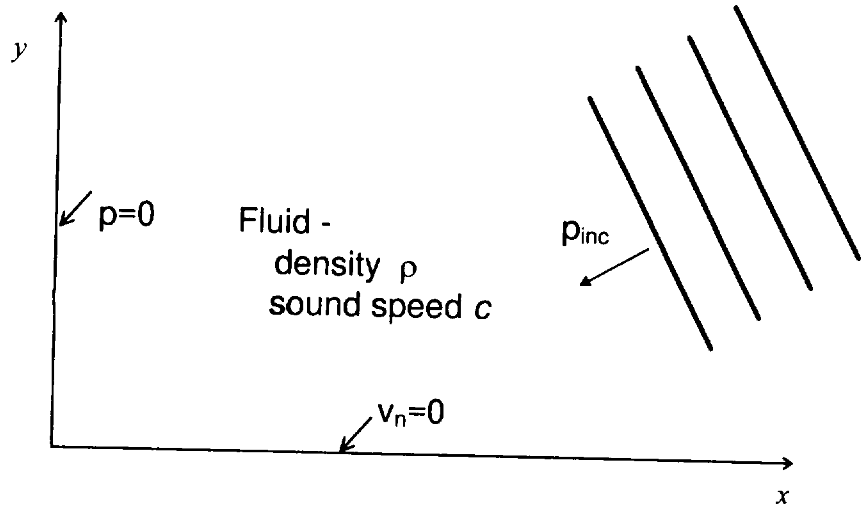


Check your answer by looking at the limiting case of a very large. Does your answer make sense? Is your answer valid in the nearfield?

Hint: Note that , for any value of R, the following relation is exact.

$$\frac{\partial}{\partial t}\left[v(t-\frac{R}{c})\right] = -c\frac{\partial}{\partial R}\left[v(t-\frac{R}{c})\right]$$

Problem 2



A continuous sinusoidal plane wave $p_{inc}(\mathbf{r},t) = p_0 \cos(k_x x + k_y y - \omega t)$ is incident at an arbitrary angle on two orthogonal semi-infinite planes as shown above (note that k_x and k_y are negative real numbers.) The *x-z* plane is rigid and immovable ($v_n = 0$) and the *y-z* plane is pressure release ($p = 0$).

a. Find an expression for the acoustic pressure everywhere in the fluid. Describe graphically the nature of the solution.

b. Could you obtain a similar solution if the *y-z* plane satisfied an impedance boundary condition? Could you obtain a similar solution if the planes were not orthogonal? **Do not actually try to solve either of these problems just tell why you think they can or can't be solved.**

Recall: $\exp(i\alpha) + \exp(-i\alpha) = 2\cos\alpha$; and $\exp(i\alpha) - \exp(-i\alpha) = 2i\sin\alpha$.

Problem 3

(a) Consider a dipole source radiating in transient mode, where the dipole moment **D**=D $\mathbf{e}_D$ is a function of time, i.e., D=D(t). [The source strength of each monopole is S(t)]. Show that the acoustic pressure at point O is

$$p(R,t) = \vec{e}_R \cdot \left(\frac{1}{R} + \frac{1}{c}\frac{\partial}{\partial t}\right)\frac{\vec{D}(t - R/c)}{R}$$

(b) Use the result in (a) to develop an expression for the transient radiation of sound from a vibrating surface with a surface pressure distribution, $p_S(t)$, and a surface normal velocity distribution, $v_{NS}(t)$.