GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - FALL Semester 2001

Acoustics
EXAM AREA

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

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

1. Assume that you are consulting for a private investigator who wants to listen to the conversation in a room from a remote location by reflecting a laser beam off of a glass window. The thickness of the glass is 3mm and its density is 2300 kg/m^3.

   a) Suppose that the sound pressure level in the room during conversation is 50dB and a common conversation frequency of 1kHz, find the transmitted pressure and the displacement of the glass plate. You can assume normal plane wave incidence and neglect the stiffness of the glass. Can you measure this displacement?

   b) What is the frequency dependence of the displacement at high frequencies?

   c) Is the relation in part b) still valid at low frequencies where the stiffness (spring constant) of the glass window needs to be taken into account? If not, find the frequency dependence at very low frequencies. Assume the spring constant of the window is given by K.

   Please write down all the assumptions you make for your solutions.
   Density of air: 1.27 kg/m^3, speed of sound in air = 330 m/sec.

2. Consider an *incoming* spherical wave pulse observed at $r = a$ in an infinite homogeneous fluid with sound speed c and density ρ. The acoustic pressure at $r = a$ is zero for $t<0$ and for $t \geq 0$ is given by

$$p(a,t) = p_0 f(t)$$

where $f(t)$ is some function with a finite duration and zero mean value.

a) Find an expression for the pressure for $r \neq 0$. Hint: It will be helpful to consider the nature of the solution after the wave passes through $r = 0$.

b) Find an expression for the pressure at $r=0$. Hint: The pressure at $r=0$ is not infinite and nonlinear effects are not involved.

3. Starting from the Rayleigh integral, derive an expression for the farfield pressure $p(r,\theta\ t)$ radiated from two concentric ring pistons of radii a_1 and a_2, ($a_2 > a_1$), and very small width w, mounted in a rigid baffle. The pistons are driven harmonically at angular frequency ω, but out of phase. Both have the same volume velocity amplitude Q. Plot the directivity when both ka_1 and ka_2 are much less than 1 and explain qualitatively your result.

Given:

$$\int_0^{\pi} \exp[j\alpha \cos\psi]\, d\psi = \pi J_0(\alpha)$$

$$\int_0^{\alpha} x\, J_0(x)\, dx = \alpha J_1(\alpha)$$

For $\alpha \ll 1$, $J_0(\alpha) = 1 - \frac{\alpha^2}{4}$ and $J_1(\alpha) = \frac{\alpha}{2}$