GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1996

ACOUSTICS
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EXAM AREA

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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 - Spring 1996

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.

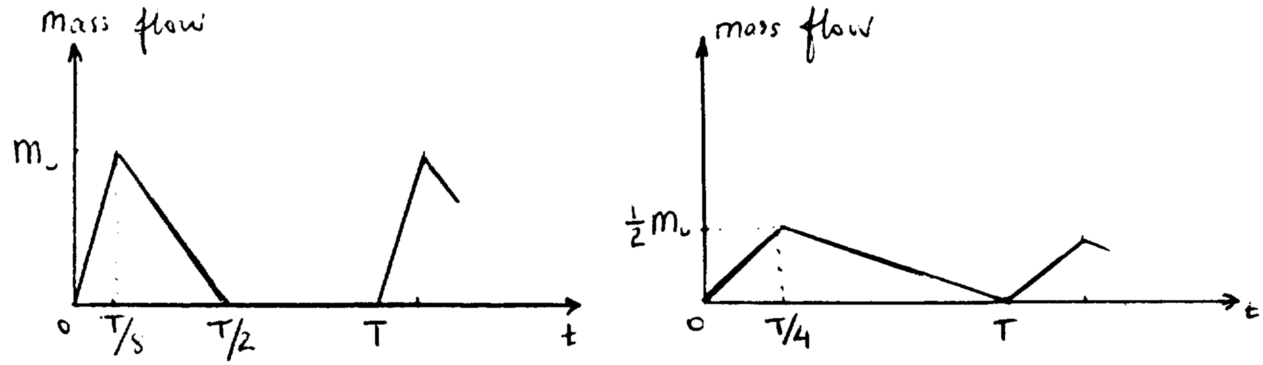
(3) Exam is closed book, and no other reference mataerials are permitted.

(4) State all assumptions clearly.

(5) Be sure that all work is legible.

Problem 1 ⟶ Grade? [Y/N]

A pneumatic tool produces a loud, repetitive, transient sound because of the sudden discharge of air through a small nozzle. The time dependence of the mass flow is shown in Figure 1(a) below. After redesign of the nozzle, the new time dependence of the mass flow is changed as indicated in Figure 1(b). (Note that the total mass flow integrated over a period remains unchanged). What reduction in peak sound pressure level can be expected as a result of this change? Estimate the peak sound pressure level, with the new nozzle, at a distance of 5 meters from the source, if m_0=100 kg/s and T=1 s and sketch the corresponding pressure waveform.



Problem 2 ⟶ Grade? [Y/N]

A useful model of traffic noise is to consider the radiation of incoherent point sources of equal sound power W arranged at regular intervals, (spacing b), on a straight line (the x-axis), in a half-space (i.e., assume rigid ground).

(a) Show that the total mean-square pressure observed at the receiver, located at a distance a from the line, is:

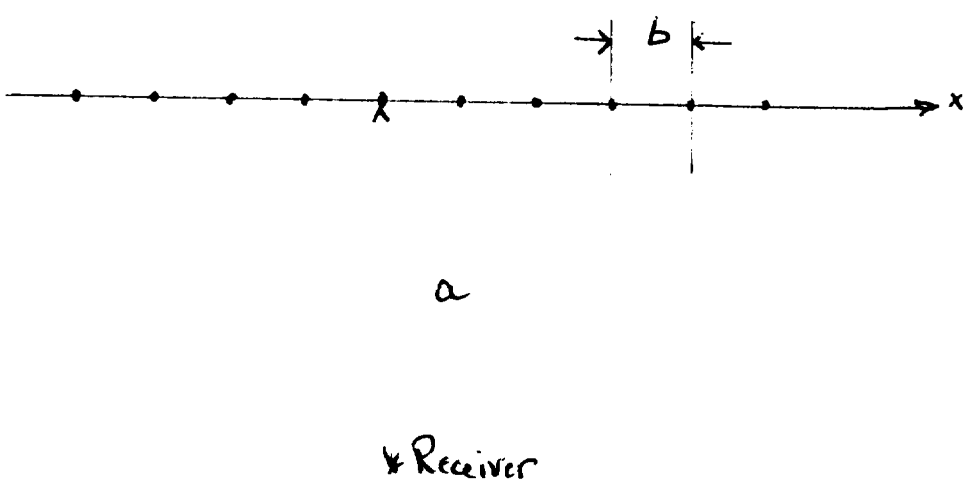
$$p^2_{rms} = \frac{W z_0}{2\pi}\left(\frac{\pi}{ab}\right)\coth\left(\frac{\pi a}{b}\right), \qquad (1)$$

where z_0 is the characteristic impedance of the medium.

(b) By taking the proper limits, show that eq.(1) reduces to either the case of a unique point source or the case of a line source, depending on how close the receiver is to the x-axis. From this two asymtotic results, plot the expected drop in sound pressure level as a function of receiver distance a from the x-axis.

Hint: The following result may prove useful:

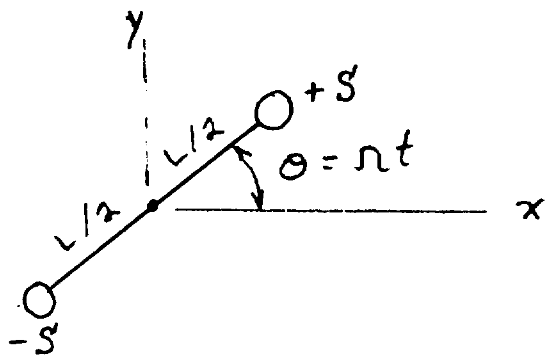
$$\sum_{n=-\infty}^{+\infty} \frac{1}{a^2+(nb)^2} = \frac{\pi}{ab}\coth\left(\frac{\pi a}{b}\right); \qquad \text{also :} \qquad \coth x = \frac{e^x + e^{-x}}{e^x - e^{-x}}.$$



Problem 3 → Grade? [Y / N] ____

Consider two monopoles having equal strength S and opposite phase. They are mounted at each end of a bar that spins in the horizontal plane at angular speed Ω (rad/s), which is substantially smaller than the frequency of the monopoles. The length L of the bar is $0.02\pi/k$. Consider a field point on the horizontal x axis at distance $R = 20\pi/k$.

A. Derive an expression for the time dependence of the acoustic pressure at this field point.
B. Derive an expression for the time-averaged intensity at this field point.



Problem 4 —> Grade? [Y/N]

(a) Discuss the design of an acoustic impedance tube for measuring the input acoustic impedance of material samples. In particular, identify the important acoustic parameters and explain how their values determine the impedance tube design.

(b) The following two-microphone configuration is a recent development in impedance tube measurements. Two microphones are mounted in the sidewall of an impedance tube that is terminated with a material of unknown specific acoustic impedance Z_S. The frequency of the test signal is f. The distance of microphone 1 from the material is d_1. Microphone 2 is mounted next to the material (d_2=0). *Outline* how the value of Z_S can be determined from the ratio of the pressures measured by the two microphones.

[$Z_S = \hat{p}/\hat{v}_{in}$ at the fluid-material boundary in the impedance tube]