Name: ________________________________

ME 513Q --- Engineering Acoustics

Exam 1 – Fall 2007 --- 11/7/2007

Note: To help you complete this exam, you may refer to your class notes, your homework, solutions provided to you and other material distributed as part of the course either in-class or via the course website, but you may not refer to the text (Kinsler, Frey, Coppens and Sanders) or to any other acoustics text

- Problem 1: ____________/20
- Problem 2: ____________/20
- Problem 3: ____________/20

Problem 1.

(i) What is sound?

(ii) The input impedance of a SDOF system is $j(5\omega - 12/\omega)$. What is the natural frequency of the system?

(iii) A linear, SDOF system is driven at frequency ω: i.e., the time phasor is $e^{j\omega t}$. Sketch the frequency spectrum of the system response.

(iv) In the expression e^{jkx}, k is the rate of increase of __________________ with __________________ .

(v) In a SDOF system, the "damped natural frequency" is ______________________ than the "undamped natural frequency".

(vi) An impedance of the form $+j\omega 17$, is referred to as a _____________________ impedance.

(vii) What is the difference between transverse wave and longitudinal wave motion?

(viii) The natural frequencies of a tensioned string are found by solving the __________________________ equation.

(ix) When the condensation is negative at a point in a sound field, the pressure at that point is _____________________ than the ambient pressure.

(x) Why are nonlinear terms neglected in the development of the wave equation?

Problem 2.

A uniform, tensioned string (tension, T, and mass per unit length, ρ_L) is rigidly fixed at $x = 0$ and is terminated by a transverse spring (spring stiffness, s) at $x = L$.

(i) Give an appropriate assumed solution for the transverse displacement of the string. Define quantities as necessary.
(ii) Draw a free body diagram of the forces acting at the string termination at $x = L$.
(iii) Give in equation form the boundary conditions that apply at $x = 0$ and $x = L$.
(iv) Use the boundary conditions in conjunction with the assumed solution to derive the transcendental characteristic equation that can be solved for the allowed wave numbers. Make sure that both terms in this equation are expressed in terms of (kL).
(v) Sketch the solution of the characteristic equation. Clearly indicate the solution points on the sketch.
(vi) Show with reference to the sketch that as the stiffness of the transverse string increases, the allowed natural frequencies of the string increase.

Problem 3.

When a plane sound wave transmits into a second fluid region at an angle of incidence greater than the critical angle, the sound field has the form

$$p(x, y, t) = Ae^{-\gamma x} e^{-jk_y y} e^{j\omega t}$$

where A is complex, γ and k_y are real, x is the coordinate normal to the interface between the two fluid media (and is positive into the second medium), y is the coordinate parallel to the interface, and the second medium has density, ρ_2 and speed of sound, c_2.

(i) Derive by using the linearized momentum equation an expression for the vector particle velocity field in the second medium.

(ii) Derive an expression for the vector, time-averaged acoustic intensity field in the second medium, and show that there is no energy flow normal to the interface in the second medium.

(iii) Sketch the spatial dependence of the sound field in the second medium.