

Name: _____

ME 513

Exam 1 – Fall 2004 --- 12/3/2004

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, 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) In the expression $e^{j\omega t}$, ω is the rate of increase of _____ with _____ .
- (iv) To predict the transient motion of a SDOF system, what two conditions must be specified?
- (v) In a SDOF system, the “damped natural frequency” is _____ than the “undamped natural frequency”.
- (vi) An impedance of the form $-j17/\omega$ is referred to as a _____ impedance.

- (vii) What is transverse wave motion?
- (viii) The natural frequencies of a tensioned string are found by solving the _____ equation.
- (ix) When the condensation is positive at a point in a sound field, the pressure at that point is _____ than the ambient pressure.
- (x) Why is convective acceleration considered to be negligible in the development of the wave equation?

Problem 2.

An incident transverse wave propagates in the positive- x direction along a uniform tensioned string (the tension in the string is T and its mass per unit length is ρ_L) and reflects from a mass-spring termination at $x = 0$.

- (i) Give an appropriate assumed solution for the displacement field in the region $x < 0$.
- (ii) Draw a free body diagram of the forces acting at the string termination at $x = 0$.
- (iii) Give in equation form the boundary conditions that apply at $x = 0$.
- (iv) Use the boundary conditions in conjunction with the assumed solution to solve for the reflection coefficient at the termination: i.e., find the ratio of the complex amplitudes of the waves traveling in the negative and positive x -directions.
- (v) Show that the magnitude of the reflection coefficient is always equal to unity for this type of termination.

Problem 3.

A sound pressure field in air has the form

$$p(x, y, z, t) = Ae^{-j\beta x} e^{-\alpha y} e^{j\omega t}$$

where A is complex and β and α are real.

- (i) Derive an expression for the vector particle velocity associated with this pressure field.
- (ii) By calculating the vector intensity of this field, show that there is no energy flow in the y direction.
- (iii) In sketch form, illustrate the spatial variation of the sound field.

Problem 4.

A piston oscillates at one end of a constant cross-sectional area tube (at $x = 0$), and the tube is terminated at $x = L$ by an absorbing surface. At a single frequency, the spatial dependence of the plane wave field in the tube is given by

$$\tilde{p}(x) = e^{-jkx} + 0.5e^{jkx}$$

where $k = \beta - j\alpha$, and both β and α are real.

- (i) Derive from first principles an expression for the spatial dependence of the particle velocity field within the tube.
- (ii) Give an expression for the specific acoustic impedance at $x = L$ in terms of real and imaginary parts.