NOTE: The exam will have many more questions than these examples.

5 Points Each, *Circle the best answer*

Assume a fluid with mass density of ρ=2000 kg/m³ and compressibility of κ=10⁻⁶ Pa⁻¹ for the questions below.

1. The phase velocity of a 1 kHz acoustic wave in the fluid in m/s is v_p=

   a) 200 b) 500 c) 1000 d) 2000 e) none above

$$v_p = \frac{1}{\sqrt{\rho_R \kappa_R}} = \frac{1}{\sqrt{(2000)(10^{-6})}} = 22.4 \text{ m/s}$$

2. The wavelength of a 1 kHz acoustic wave in the fluid is λ=

   a) 0.01 m b) 0.5 m c) 1 m d) 2 m e) none above

$$\lambda = \frac{v_p}{f} = \frac{22.4}{1000} = 0.0224 \text{ m}$$

3. The wavenumber, or spatial frequency, of a 1 kHz acoustic wave in the fluid in rad/m is β=

   a) 0.12 b) 2.2 c) 4.3 d) 12.6 e) none above

$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{0.0224} = 281 \frac{\text{rad}}{\text{m}}$$

4. The characteristic impedance of a 1 kHz acoustic wave in the fluid in N s/m³ is Z_0=

   a) 2000 b) 5000 c) 8000 d) 10^4 e) none above

$$Z_0 = \sqrt{\frac{\rho_R}{\kappa_R}} = \sqrt{\frac{2000}{10^{-6}}} = 44{,}700 \text{ Ns/m}^3$$

5. A valid pressure plane wave in the fluid would be $p(x,y,z,t) = [1\ 0\ 0]^T e^{-j12.6z} e^{-j2000\pi t}$.

   a) True b) False

→ Must equal $e^{-j\omega\sqrt{\rho_R \kappa_R}}$

$\omega = 2000\pi$ so $f = 1000$

← $\omega\sqrt{\rho_R \kappa_R} = 2000\pi\sqrt{(2000)(10^{-6})} = 281$

NOTE!

$\begin{bmatrix}0\\0\\1\end{bmatrix} e^{-j281z} e^{+j2000\pi t}$

WOULD BE VALID

6. For a mechanical mass+spring+dashpot parallel mechanical oscillator with parameters mass m=2 kg, compliance n=0.125 m/N, and damper mechanical resistance r=0.5 N/(m/s), the Q of the system is Q=

a a) 1/4 b) 1/2 c) 1 d) 8 e) none above

$$Q = \frac{\sqrt{m/n}}{r} = \frac{\sqrt{2/(1/8)}}{1/2} = 8$$

Note: mechanical series would be $Q = r\sqrt{n/m}$

7. For the scalar pressure field p(x,y,z,t)=$2y^3z$ the gradient is ∇p =

a) $[0 \;\; 6y^2z \;\; 2y^3]^T$ b) $[3x^3z \;\; 0 \;\; y^3]^T$ c) $[y^3z \;\; xy^2 \;\; z]^T$ d) $[0 \;\; 3y^2z \;\; y^3]^T$ e) none above

$$\nabla p = \begin{bmatrix} \partial/\partial x \\ \partial/\partial y \\ \partial/\partial z \end{bmatrix} 2y^3z = \begin{bmatrix} 0 \\ 6y^2z \\ 2y^3 \end{bmatrix}$$

8. For the two vectors $\mathbf{v_1}=[2\ 2\ 2]^T$ and $\mathbf{v_2}=[3\ 2\ 1]^T$ the inner product , or dot product, is

a) $[2\ {-4}\ 6]^T$ b) 10 c) 20 d) 32 e) none above

$$[2\ 2\ 2]\begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix} = 2\cdot 3 + 2\cdot 2 + 2\cdot 1 = 12$$

Assume a mechanical wave mass+spring transmission line with mass density of m_R=2 kg/m and compliance-per-unit-length of n_R=0.5 N^{-1} for the questions below.

9. The phase velocity of a 1 kHz mechanical wave in the systemin m/s is v_p=

a) 1 b) 4 c) 40 d) 400 e) none above

$$v_p = \frac{1}{\sqrt{m_R n_R}} = \frac{1}{\sqrt{(2)(\frac{1}{2})}} = 1 \text{ m/s}$$

10. The wavelength of a 1 kHz mechanical wave in the transmission line is λ=

a) 0.001 m b) 0.04 m c) 0.1 m d) 0.2 m e) none above

$$\lambda = \frac{v_p}{f} = \frac{1}{1000} = 0.001 \text{ m}$$

Assume a 2 m longpiston of 0.001 m^2 area is filled with fluid with mass density of ρ=4 kg/m^3 and compressibility of $\kappa=10^{-6}$ Pa^{-1} for the questions below.

11. The piston is equivalent to a spring with compliance in m/N of n=

a) 0.001 b) 0.004 m c) 0.04 d) 0.02 e) none above

$$n \Leftrightarrow \frac{\kappa l}{A} = \frac{(10^{-6})(2)}{0.001} = 0.002 \text{ m/N}$$