Problem 1. Circle the best answer. Each part is worth 2 Points. (20 Points)

1) The strength of a spherical source is defined as:
   a) The amount of fluid displaced per unit volume.
   b) The relationship between pressure and particle displacement.
   c) The ability for the volume level of the sound to go to eleven.
   d) The surface area of the source times the pressure amplitude.
   e) The surface area of the source times the velocity amplitude.
2) A thermocline in the ocean produces the following acoustic phenomenon:
   a) Better ability to locate fish in a pond.
   b) A massaging chair with a foot support for weary ship captains.
   c) Giant squid that eat unwary sailors.
   d) Increasing pressure of acoustic waves with depth.
   e) A potential shadow zone for submarines to hide from surface ship sonars.
3) In an acoustic doublet with both sources **in phase**, the resulting farfield pattern looks like a:
   a) Figure eight.
   b) Sinc function.
   c) Ellipse.
   d) Omnidirectional.
   e) None of the above.
4) A piston source with low *ka* can be characterized by:
   a) A very narrow beamwidth.
   b) A large number of maxima along the axis.
   c) A radiation resistance that is much larger than the radiation reactance.
   d) Being loaded with a cylindrical volume of fluid
   e) c) and d).
5) An angle of intromission can occur under the following conditions:
   a) At an interface where the impedance of medium 2 is equal to that of medium 1 but the sound speeds are different.
   b) At an interface where the impedance of medium 2 is equal to that of medium 1 but the densities are different.
   c) At an interface where the impedance of medium 2 is greater than that of medium 1 but the sound speed are equal.
   d) At an interface where the impedance of medium 2 is greater than that of medium 1 but the sound speed of medium 2 is greater than the sound speed of medium 1.
   e) At an interface where the impedance of medium 2 is greater than that of medium 1 but the sound speed of medium 2 is less than the sound speed of medium 1.
6) (True or False) The far field will occur at a larger distance as the *ka* for a source increases.
7) (True or False) If a critical angle occurs, then an angle of intromission will also occur.
8) (True or False) A critical angle will only exist when the speed of sound in the second medium is greater than the speed of sound in the first medium.
9) (True or False) The beamwidth of a disc of radius L will be larger than the beamwidth of a line of length L.
10) (True or False) If a wave is incident on an interface between two media having the same characteristic impedance, there will always be no reflected wave.

Problem 2. A wave is incident normally at an interface between two media with $z_1 = 10^6$ Rayls and $z_2 = 10^3$ Rayls at a frequency of 1 MHz.

a) (4 points) Determine the **approximate** intensity transmission coefficient.

b) (8 points) It is desired to get perfect transmission into the second medium by placing a small matching layer at the surface. Determine the length, L, of the matching layer (assume smallest thickness) and the density of the matching layer assuming $c_2 = 4\text{x}10^3$ m/s.

c) (5 points) The frequency is changed to 3 MHz. Determine the new intensity transmission coefficient into the second fluid through the matching layer.

d) (3 points) Discuss the importance of an acoustic matching layer and its applications.

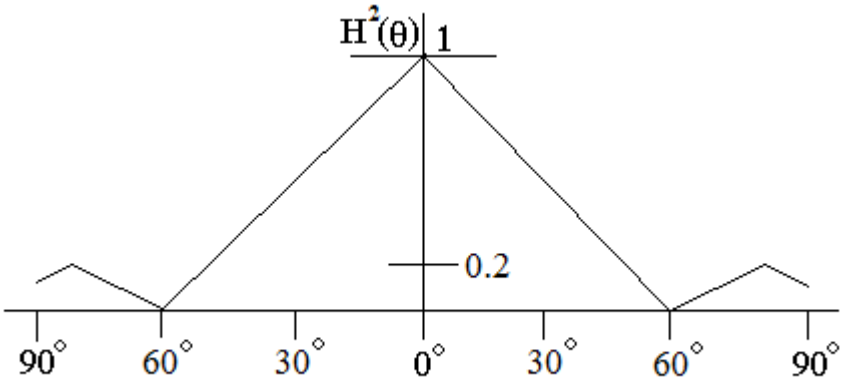
Problem 3. An ultrasonic beam is incident on a fluid/fluid interface. The impedance of the second fluid is 0.9 MRayls. A critical angle occurs at 30º incidence. At normal incidence the signal is reflected back at -20 dB referenced to the incident pressure wave.

a) (6 points) Determine the magnitude of the pressure reflection coefficient at normal incidence.

b) (8 points) If an angle of intromission also occurs, determine the impedance of the first fluid.

c) (6 points) If the sound speed in medium 1 is 500 m/s, determine the sound speed of medium 2.

Problem 4. Given the Cartesian representation of $|H(\theta)|^2$.



a) (8 points) Determine the beamwidth at -3 dB, and -10 dB (Hint calculate the main lobe in terms of a line function with $x = \theta$).

b) (7 points) Determine the directivity, *D*, if the above Cartesian representation of the directional factor represents a cone with no ϕ dependence from a baffled source. Calculate based only on the main lobe and not the side lobes (see tables on last page for integration help).

c) (5 points) Determine the level of the side lobe in dB relative to the main lobe.

Problem 5. A piston source (circular disc) is operated in a gas at a frequency of 5.46 kHz. The speed of sound in the gas is $2\pi \times 10^2$ m/s and the density of the gas is $10/\pi^2$ kg/m^3. A -10 dB beamwidth of 14.4° is measured for the source.

a) (8 points) Determine the radius of the source.

b) (5 points) Determine the **approximate** number of maxima that would be observed along the axis.

c) (7 points) Determine the **approximate** radiation resistance of the piston source.

Useful Tables

x	$\text{jinc}^2(x)$
1	1
1.16	0.7071
1.616	0.5
2.215	0.25
2.73	0.1

θ (degrees)	sin θ
7.2	0.125
14.5	0.25
30	0.5
45	$\frac{1}{\sqrt{2}}$
60	$\frac{3}{\sqrt{2}}$

$$\int x \sin x dx = \sin x - x \cos x$$

$$\int x \cos x dx = \cos x - x \sin x$$

$$\int x^2 \sin x dx = 2x \sin x + \left(2 - x^2\right) \cos x$$

$$\int x^2 \cos x dx = 2x \cos x - \left(2 - x^2\right) \sin x$$