ECE 802-MI
Fall 2004
HW 1 – due Thursday, September 9, 2004:

1. Compute the time-harmonic pressure field generated by a circular piston with a radius a = 2λ. Evaluate this pressure on a (r, z) grid defined in cylindrical coordinates that extends from 0 to 2a in the radial direction and 0 to a^2/λ in the axial direction. The grid should be either 100 x 100 points or 101 x 101 points. Use the expression in the paper by McGough et al. (which has been saved as a pdf file on the Angel site under: papers->ultrasound->McGough->mcgoughcwcircjasa) that defines the pressure as

$$p(r,z) = ve^{j\omega t}\rho c \frac{a}{\pi}\int_0^{\pi} \frac{a - r\cos\psi}{r^2 + a^2 - 2ar\cos\psi}\left(e^{-jk\sqrt{z^2+r^2+a^2-2ar\cos\psi}} - e^{-jkz}\right)d\psi \, .$$

Normalize this expression by $ve^{j\omega t}\rho c$, which is the sinusoidal particle velocity $ve^{j\omega t}$ multiplied by the characteristic acoustic impedance of the medium ρc. To evaluate the normalized pressure at each point in the (r,z) grid, use the 'midpoint rule', which is defined as $\int_a^b f(x)dx \approx \frac{b-a}{n}\sum_{i=1}^{n} f\left(\frac{b-a}{n}i - \frac{b-a}{2n}\right)$ Use a value of k = 2π (i.e., normalize all quantities by setting λ=1) for the wave number, and use n=20 for the numerical evaluations of the pressure integral.

 Turn in a printed copy of your working m-file, and also submit a mesh plot of the *absolute value* of the computed pressure field to demonstrate the result obtained with your m-file. The axes of your mesh plot should contain some meaningful information (i.e., not the default that merely represents the number of points in each direction) that indicates either the distance from the origin or the normalized distance from the origin (for example, relative to the piston radius *a* and the square of the piston radius for *r* and *z*, respectively). Although *any reasonable axes will be accepted*, please note that the axes in the posted solution will be normalized with respect to the piston radius in the lateral direction (i.e., the r-axis will range from 0 to 2) and in the axial direction, the axes will be normalized with respect to the *far field distance* $d^2/4\lambda$, where d=2a (i.e., the z-axis will range from 0 to 1). Also note that the 'mesh(cols, rows, abs(p))' command in Matlab has a strange convention in the sense that the vectors describing the axes are expected in reverse order.

2. Install the Field II program on a computer that you can use for extended periods of time (for example, all night long) without interruption. This computer should have at least a Pentium III CPU or better, it should have a fair amount of available

disk space, and it should have a working copy of Matlab with the signal processing package installed. Use whatever operating system you like. Note that, in order to display the Field II logo when you initialize with ‘field_init’, you might need to comment out the line with the ‘eval’ command and replace it with ‘load logo_field’ (no quotes) in the file ‘edit field_logo.m’.

The following m-files can be found in ‘programs->ultrasound->field II->user’s guide examples:

3. Run ‘calc_scat_multi_example.m’, and interpret the results (use layman’s terms, and do not copy the user’s guide!). Turn in the resulting figure.

4. Run ‘ele_apodization_example.m’, and then call ‘show_xdc(Th)’. Turn in the resulting figure. What does this figure show?

5. Run ‘xdc_concave_example.m’, and then call ‘show_xdc(Th)’. Turn in the resulting figure.

6. Run ‘xdc_convex_focused_array_example.m’, and then call ‘show_xdc(Th)’. Turn in the resulting figure.

7. Run ‘xdc_linear_array_example.m’, and then call ‘show_xdc(Th)’. Turn in the resulting figure.

8. Problem 3.1 in Webb.

9. Problem 3.2 in Webb.

10. Problem 3.3 in Webb.

Important Note: ***For each computer-generated result***, be sure to include a printout of your matlab code and/or a list of matlab commands that you used to obtain your results.

Next week, we will run the **cyst phantom** example from the Field II web site. Be prepared for excessive CPU usage! You should also expect a follow-up exercise that extends the results from problem #1 in this assignment.

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