Spring 2007, Aaron Lanterman

ECE 6279: Spatial Array Processing Homework 1

Due: Fri 1/26/07 (campus) or Fri 2/2/07 (video)
Late due date (20% penalty): Mon (campus) 1/29/07 or Mon 2/5/07 (video)

You are welcome to discuss approaches to the problems and solutions to difficulties you encounter with one another and with others outside the class. You can and should learn from each other as much as, and even more than, you learn from me. However, your solutions should be your own work and should be written up by yourself; feel free to discuss things, but don't be looking at someone else's paper when you are writing your solution. It's too easy to freeload that way and not learn anything. See the class website for more guidelines.

For on-campus students, homework is due at the *start* of class; for video students, please have your homework submitted by noon on the day it's due (that gives time for the distance learning staff to get it logged and on its way to me that day, so I can go through it over the weekend.)

A 20% penalty will be assessed on late homeworks (even homeworks turned in later the day it is due); I will distribute solutions shortly after class on Monday, so I will not accept solutions after that. The "late" turn in is available as an emergency buffer in case you get overwhelmed with life in general, but try not to rely on it. If you cannot make a class, please make arrangements to get your homework to me ahead of time. (A mechanism will be developed to distribute solutions to the on-campus and video students separately at appropriate times; in this sense, they are considered separate "classes.")

1 Required Problems

1. Problem 2.2 from J & D, with the following changes and observations:

   - Don't bother to "Show that indeed the formula given previously does correspond to a propagating signal." We already more-or-less showed that in class.
   - As Dan Fuhrmann noted when I took his array signal processing class at Washington Univ., part (e) is "a little ambiguous since a square pulse cannot propagate spherically in a way that the radial function $p(t, r)$ is flat at all times t. However we can assume that $s(r, t)$ is derived from a well-defined pulse, as described at the bottom p. 17."

2. Problem 2.3 from J & D, with the following tweaks:

   - To keep our notation consistent, denote the sinusoidal plane wave as $s(\vec{x}, t) = \cos(\omega_0 t - \vec{k} \cdot \vec{x} + \varphi)$. We've mostly been talking about complex exponentials in class, but don't let the real sinusoid scare you. This problem is just intended to get you thinking about sampling waves, to develop some intuition; you don't need any super-fancy theory from class to reason your way through it.

- Hint on part (d), you may find it convenient to draw lines on a $k_1 - \varphi$ plane, and see where lines intersect.
- For part (e), if you don't like the cosine, you can try a complex exponential plane wave (as from class) instead, and meditate upon $s_1 s_2^*$; I think the solution is a little clearer that way, but your mileage may vary.

3. Problem 2.4 from J & D, with the following observations:
   - In part (b), it's impossible to find a closed form solution. Show how you could find solutions graphically by arranging your necessary condition so that you have kr on one side of the equation and a cotangent on the other; you could then plot the cotangent and the line, and see where they intersect. (I'm not asking for any actual numeric values; just show me how you could do it.)
   - In part (c), be careful about interpreting the critical points; notice that the maxima and minima alternate. You may need to spend some time meditating upon the nature of the cotangent function, and where the line intersects it for large r.