BENG280A, Principles of Biomedical Imaging 10/11/05
Fall Quarter 2005

HOMEWORK #3
Due at the start of Class on Thursday 10/20/05

Readings:
1. Review last week's reading as necessary. Read Section 2.8 and Sections 3.1 through 3.3.

Problems:

1. Problem 2.6.

2. Problem 2.10 (parts a, b and d).

3. Use the convolution and modulation theorems to find and graph the transforms of the following functions: $\mathrm{sinc}(x) * \mathrm{sinc}(2x)$ and $\left[\mathrm{sinc}(x)\cos(10\pi x)\right]^2$

4. Sketch the function $g(x,y) = \exp(-j2\pi(3x+2y))\cos(2\pi 6x)$. Find and sketch its 2D Fourier Transform of Hint: the function is separable.

5. Consider the 2D object $m(x,y) = \sin c(x)\sin c(y)\left[\cos(8\pi x) + \cos(16\pi y)\right]$
   (a) Sketch *m(x,y)*.
   (b) Derive and sketch the 2D Fourier transform of *m(x,y)*.
   (c) Define $h(x,y) = \left[m(x,y)\cos(8\pi x)\right] ** \left[\sin c(2x)\sin c(2y)\right]$. Sketch and give a simple expression for *h(x,y)*. Give an intuitive explanation for your result.

MATLAB Exercise:.
Steps:
1. First download the file BE280Ahw1im.mat from the course website.
2. Load the image into MATLAB with the command: *load BENG280Ahw1im.*
3. Compute the 2D Fourier transform of the image with the command *Mf = fft2(Mimage);* where the 2D transform will now be stored in the variable *Mf*. Remember to add the semi-colon at the end of the command, otherwise MATLAB will display all the numbers in the matrix! The command *fft2* puts the zero-frequency value of the transform at the first indices of the matrix. For display it's convenient to put the zero-frequency value in the center of the matrix. To do this, type *Mf = fftshift(Mf);*

4. ***Aliasing***

(a) Aliasing in the x-direction. Pick out every other column in the transform matrix and take the inverse transform. The steps are as follows: (the >> represents the MATLAB prompt)
\>> alias_span = 1:2:256;

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>> Mf2 = zeros(256,256);
>> Mf2(:,alias_span) = Mf(:,alias_span);
>> Mf2 = fftshift(Mf2);
>> M_aliasx = ifft2(Mf2);
>> imagesc(abs(M_aliasx)); % This will be an image showing aliasing in the x-direction.
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(b) **Demonstrate aliasing in the y-direction**. **Hand in code and image.**

(c) **Demonstrate aliasing in the x and y directions**. **Hand in code and image.**

(d) Show one additional example of aliasing, where you take every Nth sample (e.g. every 4th or 8th sample)**.** Show that the resultant image is what you would expect from sampling theory.