CS474/674 Image Processing and Interpretation
Sample Midterm Exam

Name:_____

1. **[25 points]** True/False Questions – To get credit, **you must give brief reasons for each answer!**

T F The filter shown below is a smoothing filter.

```
1 2 1
2 1 2
1 2 1
```

T F Assuming an NxN image, the complexity of 2D FFT is $O(N^2 \log N)$.

T F The magnitude of the FT carries more information than its phase.

T F The Nyquist theorem assumes band-limited functions only.
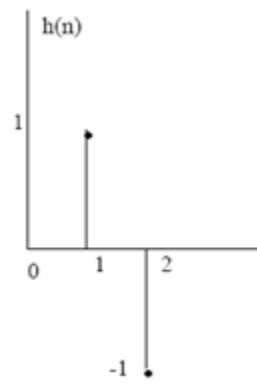
T F Unsharp masking is a special case of high boost filtering.

2. **[15 points]** State and prove the convolution theorem in the continuous case. For simplicity, assume 1-D functions.

3. **[15 points]** Find and plot the discrete convolution of the following discrete sequences:

x(n)

0   1   2   3

4 samples

h(n)

0   1   2

-1
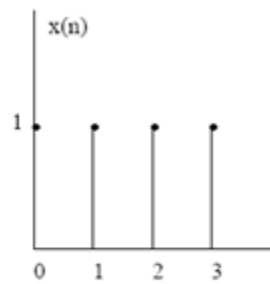
2 samples

4. [20 points]. A 3 bits/pixel image of size 5x5 is given below. Find the following: (a) the output of a 3x3 averaging filter at (1,1), (b) the output of a 3x3 median filter at (1,1) and (c) the gradient magnitude at (1,1) using the Sobel masks shown below.

```
                    IMAGE
  y     x=|  0    1    2    3    4    |
  ||       |                         |
  ---------------------------------------
  0        |  3    7    6    2    0   |
           |                         |
  1        |  2    4    6    1    1   |
           |                         |
  2        |  4    7    2    5    4   |
           |                         |
  3        |  3    0    6    2    1   |
           |                         |
  4        |  5    7    5    1    2   |
           |                         |
  ---------------------------------------
```

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

4. **[15 points]** What is the FT of $\cos(4\pi x)+\cos(10\pi x)$? How many samples should we obtain according to the Nyquist theorem in order to avoid aliasing?

5. [10 points] Given the 3x3 image shown below, compute the histogram equalized image (assume that the gray-levels are in the range [0..7]). Show all the steps.

3 1 1
1 7 6
0 2 1

7. Graduate Students Only [10 points] The pixel intensity values of a gray level image have the probability density function $p_r(r)$ given by $p_r(r)=2(1-r)$, for $0 \le r \le 1$, and zero otherwise. It is desired to transform the gray levels of the image so that they have the probability density function $p_z(z)=2z$, for $0 \le z \le 1$, and zero otherwise. Assume that r and z are continuous random variables. Find the transformation that accomplishes that.