ECE 5273
Test 1

Wednesday, March 9, 2016
4:30 PM - 5:45 PM

Spring 2016 Name: SOLUTION

Dr. Havlicek Student Num: _____

Directions: This is an open notes test. You may use the official course lecture notes and a calculator. Other materials are not allowed. You have 75 minutes to complete the test. All work must be your own.

SHOW ALL OF YOUR WORK for maximum partial credit!

GOOD LUCK!

SCORE:

1. (20) _____
2. (20) _____
3. (20) _____
4. (20) _____
5. (20) _____

_____

TOTAL (100):

_____

On my honor, I affirm that I have neither given nor received inappropriate aid in the completion of this test.

Name: _____ Date: _____

1. **20 pts.** True or False. Mark *True* only if the statement is **always** true.

TRUE	FALSE	
X		(a) **2 pts.** The YCbCr color space was originally used for color TV so that black and white TV's could continue to function by receiving and displaying only the Y component.
	X	(b) **2 pts.** Any digital image can be exactly reconstructed from its histogram.
X		(c) **2 pts.** For a given structuring element or window, the binary Median and Majority filters are identical.
	X	(d) **2 pts.** Blob coloring is a simple method for generating the histogram of a color image.
X		(e) **2 pts.** The binary OPEN and CLOSE filters generally do not affect the overall sizes of objects that are sufficiently large.
X		(f) **2 pts.** Snapping a picture with your cell phone camera is an example of reflection imaging.
	X	(g) **2 pts.** MRI is a type of absorption imaging. Emission
	X	(h) **2 pts.** The 2D centered DFT is useful and intuitive because it displays the highest spatial frequencies in the center of the DFT magnitude image. Lowest
X		(i) **2 pts.** The 2D discrete-space Fourier transform (DSFT) of any digital image is periodic.
OH my!		(j) **2 pts.** Trump will be president of the United States.

2. **20 pts.** Consider the 4×4 image $\mathbf{I}$ shown below, where the allowable range of gray levels is $0 \leq I(i,j) \leq 15$:

$$\mathbf{I} = \begin{array}{|c|c|c|c|} \hline \mathbf{2} & \mathbf{1} & \mathbf{2} & \mathbf{15} \\ \hline \mathbf{1} & \mathbf{0} & \mathbf{2} & \mathbf{14} \\ \hline \mathbf{15} & \mathbf{13} & \mathbf{13} & \mathbf{14} \\ \hline \mathbf{15} & \mathbf{15} & \mathbf{14} & \mathbf{15} \\ \hline \end{array}$$

Construct a new image $\mathbf{K}$ by applying the histogram shaping algorithm to make the histogram more "ramp like." The **desired** histogram shape is given by:

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H_{\mathbf{K}}(k)$	1	0	0	2	0	0	0	3	0	0	0	4	0	0	0	6

Show the new image $\mathbf{K}$ and its histogram $H_{\mathbf{K}}$ in the spaces provided below.

$$\mathbf{K} = \begin{array}{|c|c|c|c|} \hline 7 & 3 & 7 & 15 \\ \hline 3 & 0 & 7 & 15 \\ \hline 15 & 11 & 11 & 15 \\ \hline 15 & 15 & 15 & 15 \\ \hline \end{array}$$

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$H_{\mathbf{K}}(k)$	1	0	0	2	0	0	0	3	0	0	0	2	0	0	0	8

Work space is provided on the next page.

Workspace for Problem 2:

$J =$

6/16	3/16	6/16	16/16
3/16	1/16	6/16	11/16
16/16	8/16	8/16	11/16
16/16	16/16	11/16	16/16

$K =$

7	3	7	15
3	0	7	15
15	11	11	15
15	15	15	15

For I :

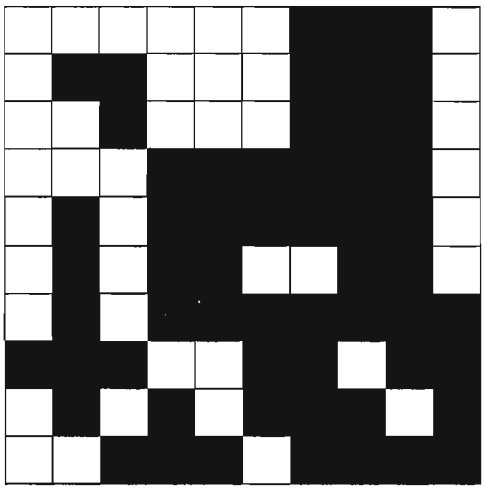
k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H(k)	1	2	3	0	0	0	0	0	0	0	0	0	0	2	3	5
p(k)	1/16	2/16	3/16	0	0	0	0	0	0	0	0	0	0	2/16	3/16	5/16
P(k)	1/16	3/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	6/16	8/16	11/16	16/16

Desired:

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H(k)	1	0	0	2	0	0	0	3	0	0	0	4	0	0	0	6
p(k)	1/16	0	0	2/16	0	0	0	3/16	0	0	0	4/16	0	0	0	6/16
P(k)	1/16	1/16	1/16	3/16	3/16	3/16	3/16	6/16	6/16	6/16	6/16	10/16	10/16	10/16	10/16	16/16

3. **20 pts.** Consider the 10×10 binary image $\mathbf{I}$ shown below, where BLACK = LOGIC ONE and WHITE = LOGIC ZERO.

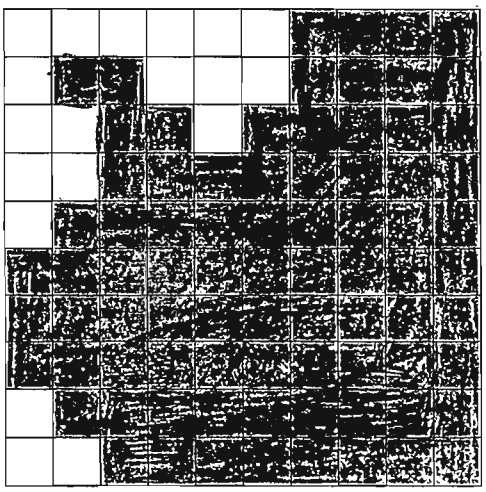
$\mathbf{I}$ =



Form a new binary image $\mathbf{J}$ = CLOSE($\mathbf{I}, \mathbf{B}$) by applying a binary morphological CLOSE filter with structuring element $\mathbf{B}$ = CROSS(5). Handle edge effects by replication.

Show the new image $\mathbf{J}$ in the space provided below:

$\mathbf{J}$ =



There is work space on the next page.

$B =$ 

Workspace for Problem 3:

DILATE (I, B)

0	1	1	0	0	1	1	1	1	1
1	1	1	1	0	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1

J = ERODE [DILATE (I, B), B]

0	0	0	0	0	0	1	1	1	1
0	1	1	0	0	0	1	1	1	1
0	0	1	1	0	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
0	1	1	1	1	1	1	1	1	1
0	0	1	1	1	1	1	1	1	1

4. **20 pts.** Consider a 6×6 digital image $\mathbf{I}$ given by

$$I(m,n) = 3 + 12\delta(m,n) + \cos\left[\frac{2\pi}{6}(m+2n)\right] + 2\cos\left[\frac{2\pi}{6}(2m-n)\right],$$

where m = column and n = row.

(a) **10 pts.** Find a closed form expression for the DFT $\tilde{\mathbf{I}}$.

From the DFT pairs on pp. 126-129 of the notes, we have

$3 \overset{DFT}{\longleftrightarrow} 108\delta(u,v)$ $\qquad$ $12\delta(m,n) \overset{DFT}{\longleftrightarrow} 12$

$\cos\left[\frac{2\pi}{6}(m+2n)\right] \overset{DFT}{\longleftrightarrow} 18\left[\delta(u-1,v-2) + \delta(u+1,v+2)\right]$

$2\cos\left[\frac{2\pi}{6}(2m-n)\right] \overset{DFT}{\longleftrightarrow} 36\left[\delta(u-2,v+1) + \delta(u+2,v-1)\right]$

So:

$$\tilde{I}(u,v) = 108\delta(u,v) + 12 + 18\left[\delta(u-1,v-2) + \delta(u+1,v+2)\right] + 36\left[\delta(u-2,v+1) + \delta(u+2,v-1)\right]$$

(b) **10 pts.** Show the real and imaginary parts of the **centered** DFT array in the space provided below:

$\tilde{\mathbf{I}} =$

v \ u	-3	-2	-1	0	1	2
-3	12	12	12	12	12	12
-2	12	12	30	12	12	12
-1	12	12	12	12	12	48
0	12	12	12	120	12	12
1	12	48	12	12	12	12
2	12	12	12	12	30	12

$+ \sqrt{-1} \times$

v \ u	-3	-2	-1	0	1	2
-3	0	0	0	0	0	0
-2	0	0	0	0	0	0
-1	0	0	0	0	0	0
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0

5. **20 pts.** Draw lines to match the images with their log-magnitude DFT spectra.