ECE 5273
Test 1

Wednesday, March 22, 2006
5:00 PM - 6:15 PM

Spring 2006 Name: SOLUTION

Dr. Havlicek Student Num: _____

Directions: This is an open book, open notes test. 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:

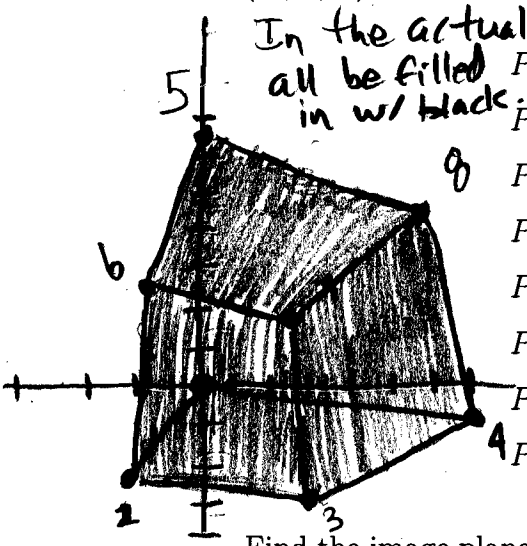
1. (20) _____
2. (25) _____
3. (25) _____
4. (30) _____

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.** A scene consisting of a black cube against a white background is imaged with an ideal pinhole camera having a focal length of $f = 35$ mm. The world coordinates (X, Y, Z) of the cube vertices are given by:



$$
\begin{aligned}
P_1 &= (0.00000\text{ m}, 0.00000\text{ m}, 1.00000\text{ m}),\\
P_2 &= (-0.17101\text{ m}, -0.19857\text{ m}, 1.42583\text{ m}),\\
P_3 &= (0.29884\text{ m}, -0.27084\text{ m}, 1.58081\text{ m}),\\
P_4 &= (0.46985\text{ m}, -0.07227\text{ m}, 1.15499\text{ m}),\\
P_5 &= (0.00000\text{ m}, 0.45315\text{ m}, 1.21131\text{ m}),\\
P_6 &= (-0.17101\text{ m}, 0.25459\text{ m}, 1.63713\text{ m}),\\
P_7 &= (0.29884\text{ m}, 0.18232\text{ m}, 1.79212\text{ m}),\\
P_8 &= (0.46985\text{ m}, 0.38088\text{ m}, 1.36630\text{ m}).
\end{aligned}
$$

Find the image plane coordinates of the projections of the vertices and carefully sketch the image that is obtained on the camera focal plane.

$(x,y) = \frac{f}{Z}(X,Y)$

$P_1: (x,y) = \frac{35}{1000}(0,0) = (0,0)$

$P_2: (x,y) = \frac{35}{1425.83}(-.17101, -.19857) = (-4.1978, -4.8743)\text{ mm}$

$P_3: (x,y) = \frac{35}{1580.81}(.29884, -.27084) = (6.6165, -5.9965)\text{ mm}$

$P_4: (x,y) = \frac{35}{1154.99}(.46985, -.07227) = (14.238, -2.1900)\text{ mm}$

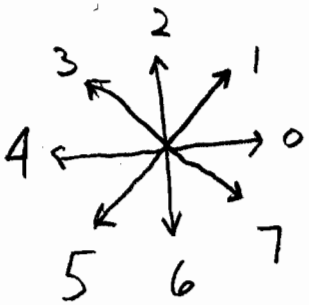
$P_5: (x,y) = \frac{35}{1211.31}(0, .45315) = (0, 13.093)\text{ mm}$

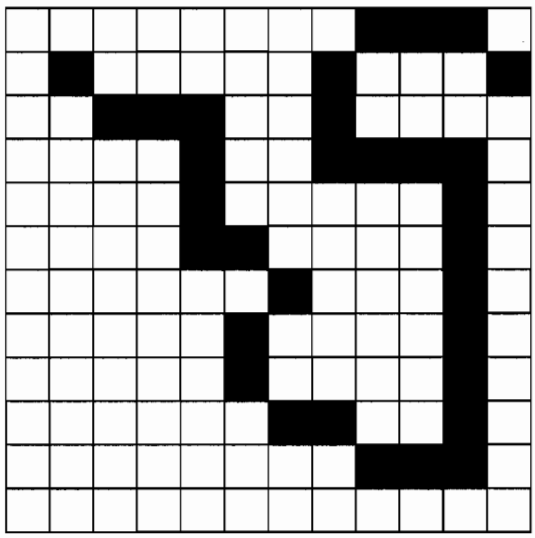
$P_6: (x,y) = \frac{35}{1637.13}(-.17101, .25459) = (-3.6560, 5.4428)\text{ mm}$

$P_7: (x,y) = \frac{35}{1792.12}(.29884, .18232) = (5.8363, 3.5607)\text{ mm}$

$P_8: (x,y) = \frac{35}{1366.3}(.46985, .38088) = (12.036, 9.7569)\text{ mm}$

2. **25 pts.** Consider the binary contour image shown below, where white represents LOGIC_ZERO and black represents LOGIC_ONE.





(a) **10 pts.** Let the upper left pixel have coordinates (row,col) = (0,0) and consider that the LOGIC_ONE pixel located at (1,1) is the initial pixel. Give a chain code for the contour.

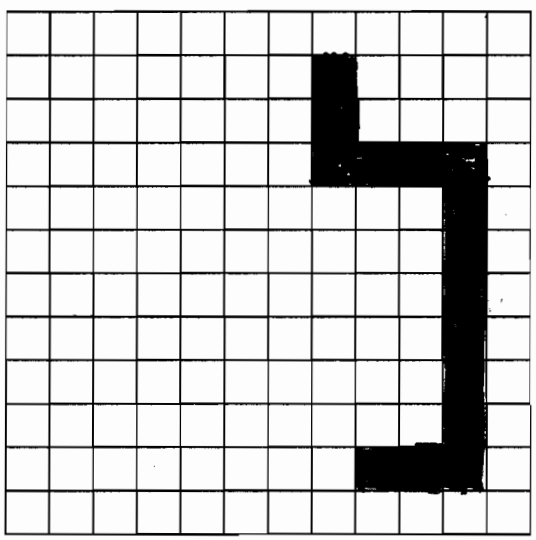
(1,1) 7 0 0 6 6 6 0 7 5 6 7 0 7 0 0

2 2 2 2 2 2 2 2 4 4 4 2 2 1 0 0 7 3

Workspace for Problem 2...

(b) **15 pts.** Four-conntected Blob Coloring (connected components analysis) is applied to the image with minor region removal. Show the result below.

The "diagonal" connections in the contour are breaks between blobs, since this is a four connected algorithm. After coloring and minor region removal, only the largest blob will remain.



3. **25 pts.** Consider the 4×4 images $\mathbb{I}$ and $\mathbb{I}'$ shown below, where the allowable range of gray levels is $0 \leq I(i,j), I'(i,j) \leq 15$:

$$\mathbb{I} = \begin{array}{|c|c|c|c|} \hline 10 & 3 & 2 & 1 \\ \hline 4 & 3 & 2 & 10 \\ \hline 3 & 4 & 9 & 9 \\ \hline 2 & 1 & 4 & 9 \\ \hline \end{array} \qquad \mathbb{I}' = \begin{array}{|c|c|c|c|} \hline 15 & 14 & 2 & 1 \\ \hline 14 & 15 & 2 & 1 \\ \hline 14 & 2 & 1 & 0 \\ \hline 2 & 1 & 0 & 0 \\ \hline \end{array}$$

Construct a new image $\mathbb{J}$ by applying the histogram matching algorithm to shape the histogram of image $\mathbb{I}$, where the desired shape is given by the histogram of the image $\mathbb{I}'$. Show the new image $\mathbb{J}$ and its histogram $H_{\mathbb{J}}$ in the spaces provided below. Work space is given on the next page.

$$\mathbb{J} = \begin{array}{|c|c|c|c|} \hline 15 & 2 & 1 & 0 \\ \hline 2 & 2 & 1 & 15 \\ \hline 2 & 2 & 14 & 14 \\ \hline 1 & 0 & 2 & 14 \\ \hline \end{array}$$

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

Workspace for Problem 2...

Work Space:

$\mathbb{II}$

10	3	2	1
4	3	2	10
3	4	9	9
2	1	4	9

$\mathbb{II}_1$

16/16	8/16	5/16	2/16
11/16	8/16	5/16	16/16
8/16	11/16	14/16	14/16
5/16	2/16	11/16	14/16

$n(i,j) = J(i,j)$

15	2	1	0
2	2	1	15
2	2	14	14
1	0	2	14

for $\mathbb{II}'$:

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

for $\mathbb{II}$:

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

for $\mathbb{II}'$:

n	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$P'(n)$	3/16	7/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	11/16	14/16	16/16

$$J_1(i,j) = \sum_{k=0}^{I(i,j)} p(k) \qquad P'(n) = \sum_{k=0}^{n} p'(k)$$

$$J(i,j) = n(i,j) = \arg\min_{n} \left[P'(n) \geq J_1(i,j) \right]$$

4. **30 pts.**

Match the images $\mathbb{I}_2$, $\mathbb{I}_4$, and $\mathbb{I}_6$ shown on page 8 with their centered log-magnitude DFT's $\widetilde{\mathbb{I}}_1$ $\widetilde{\mathbb{I}}_3$, and $\widetilde{\mathbb{I}}_5$, which are also shown on page 8.

(a) **10 pts.** DFT[$\mathbb{I}_2$] = $\widetilde{\mathbb{I}}_3$

(b) **10 pts.** DFT[$\mathbb{I}_4$] = $\widetilde{\mathbb{I}}_5$

(c) **10 pts.** DFT[$\mathbb{I}_6$] = $\widetilde{\mathbb{I}}_1$

- First I look at $\mathbb{I}_4$. Most of the rings are oriented like this:  .

There is almost no (( )) orientation, so DFT should not show ↔ because of the horizontal black line at the bottom, DFT will show ↕.

$\Rightarrow \widetilde{\mathbb{I}}_5$.

- Now I look at $\mathbb{I}_6$. ACTONTOWN will make DFT show lots of  .

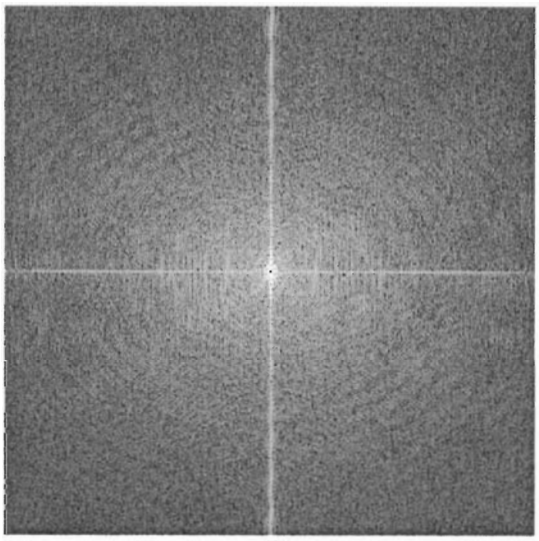
(O) will make DFT show lots of 

$\Rightarrow \widetilde{\mathbb{I}}_1$.

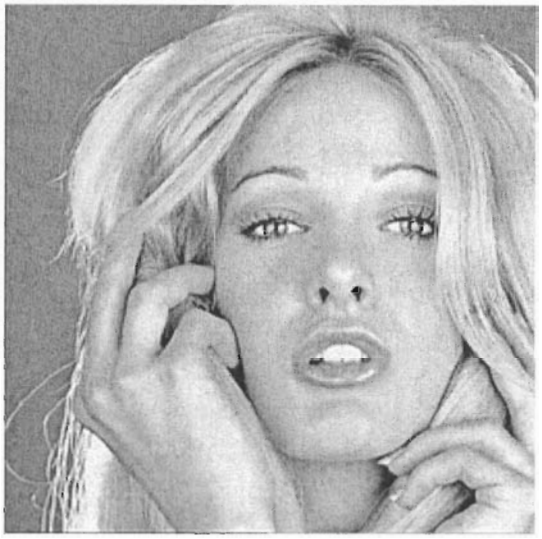
- Finally for Tifanny ($\mathbb{I}_2$): Hair and fingers: 

$\Rightarrow \widetilde{\mathbb{I}}_3$.

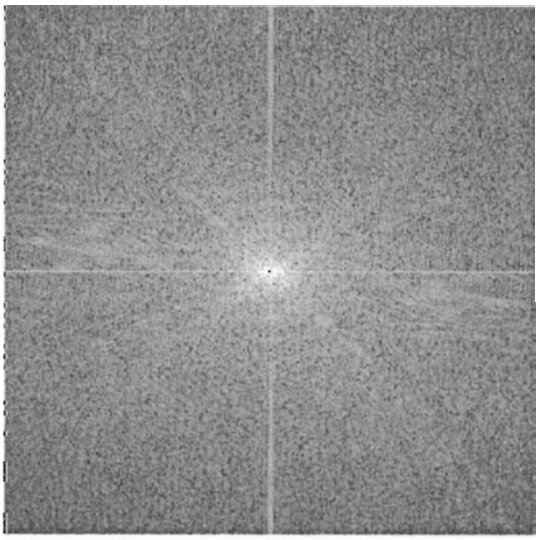
$\widetilde{\mathbb{I}}_1$



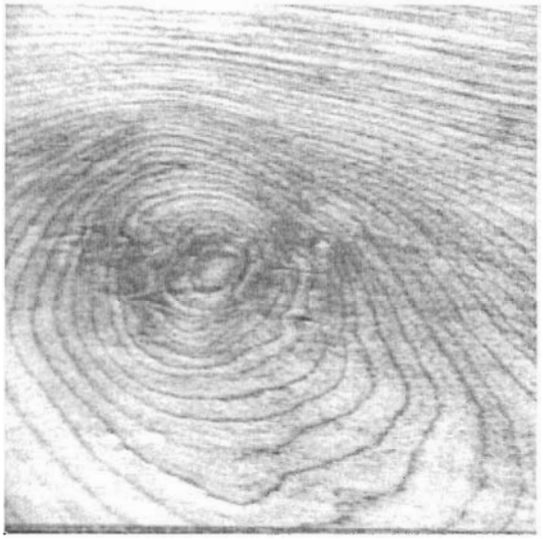
$\mathbb{I}_2$



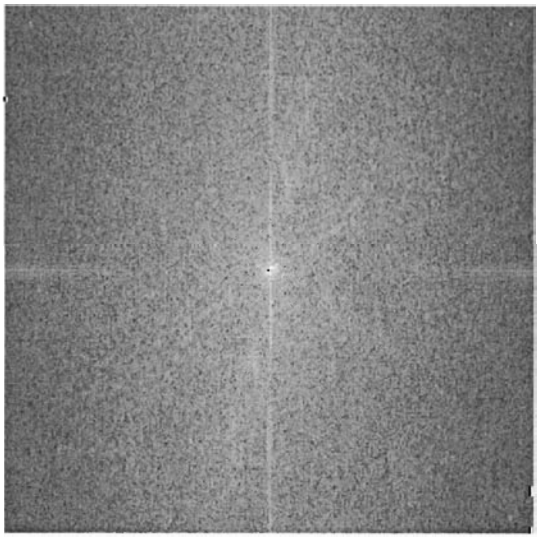
$\widetilde{\mathbb{I}}_3$



$\mathbb{I}_4$



$\widetilde{\mathbb{I}}_5$



$\mathbb{I}_6$