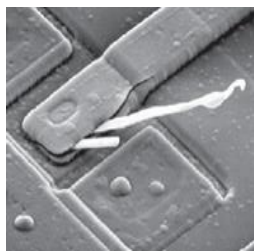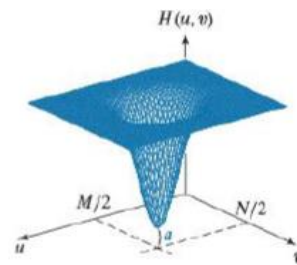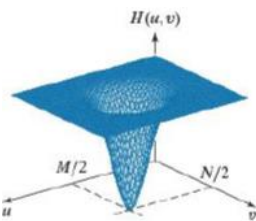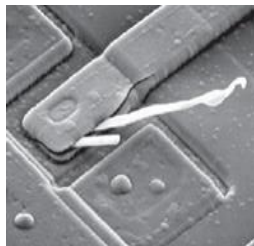(1) (15%) What are the corresponding amplitude spectrum(a-e) for the following images (1-5)?
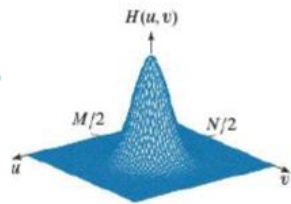
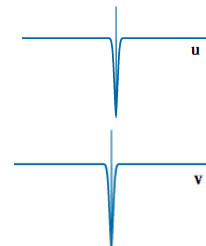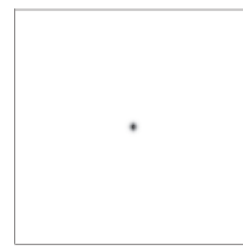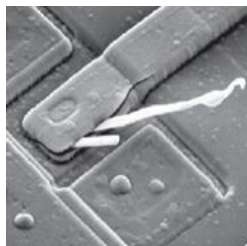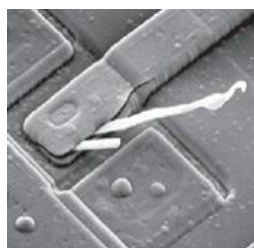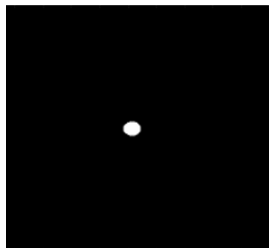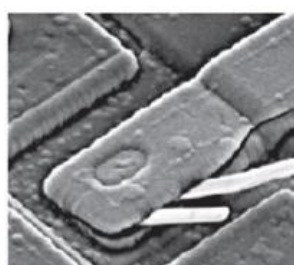
(a)

(b)

(c)

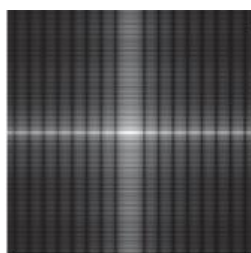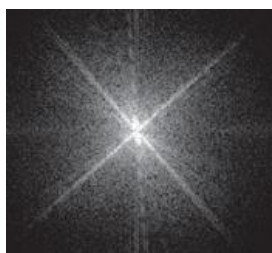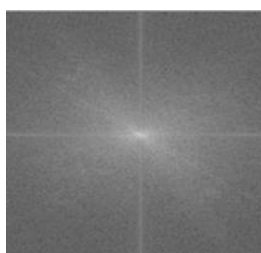(d)

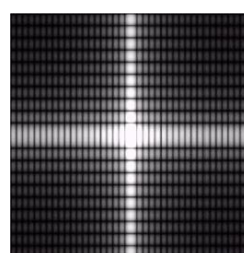(e) (f) (g) (h) (i)

Corresponding Figures:

(1) (2) (3) (4)

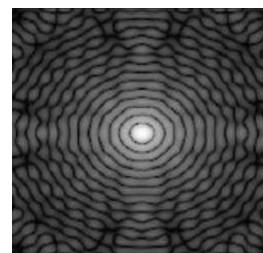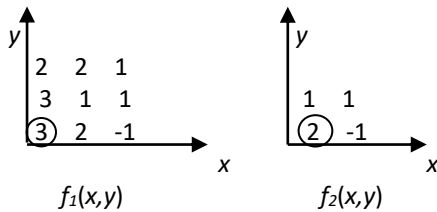(5) (6) (7) (8) (9)

(2) (15%) what are the results of convolution $f_1(x,y) * f_2(x,y)$ and correlation $f_1(x,y) \circ f_2(x,y)$? Using ◯ to represent the origin point of (0,0).

```
y
|  2  2  1
|  3  1  1
| ③  2 -1
|_____ x
   f₁(x,y)
```

```
y
|  1  1
| ②  -1
|_____ x
   f₂(x,y)
```

(3) (15%) If the V set is defined as {1}, (a) please decide how many connected components for the following image under 4-adjacent, 8-adjacent, and m-adjacent? (b) what is the minimum distance between (p) pixel and (q) pixel under 4-adjacent, 8-adjacent, and m-adjacent definitions?

(q)

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

(p)

(4) (15%) please design point operations (transformation function) or filtering masks (3x3) for the following requests.
    (a) An enhancement filter for dark images;
    (b) A noise removing filter for salt-and-pepper noise degraded images;
    (c) A noise removing filter for Gaussian noise degraded images;
    (d) A Laplacian image sharpening filter;
    (e) A band reject filter (reject bandwidth between B1 and B2).

(5) (15%) A gray level image with size of 5x5 and 8 (0~7) different intensity levels, please use histogram equalization approach to enhance the contrast, and show the newly enhanced image.

3	3	5	5	6
3	3	5	5	6
3	3	5	6	6
2	3	4	4	3
2	2	4	4	3

(6) (15%) Apply a Sobel edge detector to find edges of the matrix. What are the angle at each pixel?

0	0	0	0	0
0	1	1	1	0
0	0	4	4	0
0	0	4	4	0
0	5	5	5	0
0	0	0	0	0

(7) (15%) Describe the four main steps for Canny edge detector, and describe the purpose for each step.