1. (17%) Evaluate the linear convolution ($h*f$) (8%) and 3×3 circular convolution ($h \otimes f$) (9%) of h and f below. The shaded grids indicate the origin (0,0) of the image spatial coordinate.

$h(x,y)$

1	-1	0
-1	0	0
0	0	0

$f(x,y)$

1	2	*3*
4	**5**	4
3	2	1

2. (10%) Consider the design of Wiener filter $H_W(u,v) = \hat{F}(u,v)/G(u,v)$. Assume the degradation function is a 2nd-order Butterworth lowpass filter (β=1) with cutoff frequency D_0. (a) Determine the SNR if the overall gain of Wiener filter is 1.2 at D_0 (5%). (b) What is the DC gain of the Wiener filter in (a) (5%)?

3. (14%) (a) Determine the values of H, S and I in HSI color model for a color with normalized (R,G,B) = (0.6,0.7,0.5) (6%). (b) Determine the values of C, M, Y and K in CMYK model for this color (8%).

4. (9%) Prove the circular convolution property of 2D inverse DFT, that is, inverse DFT$\{F(u,v)H(u,v)\}$ = $f(x,y) \otimes h(x,y)$, given $F(u,v)$ is $M \times N$ DFT of $f(x,y)$, $H(u,v)$ is $M \times N$ DFT of $h(x,y)$, and operator $\otimes$ indicates $M \times N$ circular convolution.

5. (30%) Briefly describe
   (a) the differences of isopreference curves between crowd and Lena's face (5%),
   (b) the assumption for the degradation function and the added noise in the degradation model (5%)
   (c) the differences between the band filter and the notch filter (5%),
   (d) the mechanism of ringing effect caused by ideal filter (5%).
   (e) the scheme for determining the direction of motion from an image degraded by uniform-linear motion blurring (5%).
   (f) Consider a real 4×4 function $f(x,y)$ and its 4×4 DFT $F(u,v)$. Determine $g(x,y) = \text{DFT}^{-1}\{F(u,v)(j)^u\}$, expressed in $f(x,y)$ (5%).

6. (16%) Consider a 3 bits/pixel image f_r (size 10×10) with the gray levels $0 \le r_i \le 7$, $i = 0, \ldots, 7$. The number of pixels (n_i) with gray level r_i is: n_0=10, n_1=30, n_2=25, n_3=20, n_4=15, n_5=n_6=n_7=0. (a) Determine the intensity transformation function $z = T(r)$ to produce the output image f_z with the new histogram (probability density function) {0.2 0.2 0.1 0.1 0.1 0.1 0.1 0.1} (8%). (b) Determine the actual histogram of the output image (8%).

7. (9%) Consider the image in Fig 7A. Sketch the intensity transformation curves for generating the output images in Figs 7B – 7D.


Fig 7A


Fig 7B


Fig 7C


Fig 7D