**Final Examination: ESE 558 Digital Image Processing**
Date: 5/15/2001, Duration: 2 hours, Spring 2001
SUNY at Stony Brook, Murali Subbarao, Max. Marks: 20

This test is open-text books. No other reference materials are allowed. Note: RK and GW respectively denote the text books by Rosenfeld & Kak and Gonzalez & Woods. In answering the following questions, demonstrate your understanding of the material by writing all intermediate steps to get full credit.

1. *(2+1 points) GW, Ch. 4, Histogram Equalization*
   (a) Given a 256x256 gray level image with 8bits/pixel, describe an explicit computational algorithm or a C program for historgram equalization.
   (b) How would you extend your algorithm to color images?

2. *(2 points) GW, Ch 4, Color Models*
   A color digital image represented in RGB model has 8 bits/pixel in each color band. The color of a pixel is (50,100,150). Find the values of the pixel in the HSI model.

3. *(3 points) GW, Ch. 6, Image compression*
   In the JPEG sequential baseline system of compression, find the encoding of the following 1-D DCT block. Show all steps for deriving each entry to demonstrate your understanding. Just writing correct answer is not sufficient. Assume that the DC coefficient of the previous block is -10.
   `[ -22 4 0 -2 0 0 0 -5 EOB ]`

4. *(3+1 points) GW, Ch. 6, Huffman-Shift code*
   A 3 bits/pixel 100x100 image is compressed by Huffman-shift coding the gray level values. Derive the best possible Huffman-shift code with a total of 5 symbols including one shift symbol. The histogram of the image is given below.

| Gray value : | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Frequency count: | 2000 | 1800 | 2500 | 1500 | 1200 | 200 | 500 | 300 |

   (b) What is the total size of the compressed image? (excluding the Huffman-shift code table).

5. *(5 points) RK Ch 7 : Image Restoration*
   On page 271 in the text book by Rosenfeld and Kak, the transfer function for motion blur in photography is derived. The derivation assumes that the shutter of the camera requires negligible time to change from closed to open and vice versa. Replace this assumption with a new one as follows: The area of the shutter increases linearly from 0 to 1 unit during the time -T/2 to 0, and then decreases linearly from 1 to 0 during the time 0 to T/2. Derive a new transfer function using the new assumption.

6. *(3 points) RK Ch 8 : Image Reconstruction*
   The value of a function $f(x,y)$ is 1 inside an outer square of diagonal length 4 except inside an inner square of diagonal length 2 where the value is 2. Both squares are centered at the origin and the diagonals are along the x and y axes. $f(x,y) = 0$ outside the outer square. Find the Radon transform $P_0(t)$ of $f(x,y)$ (i.e. find the projection onto the x-axis).