Important: This is an open book test. You can use any books, notes, or paper, but not exchange anything with other students. You are not allowed to use any electronic/communication devices, including a calculator. *Do not log into the computer during the test*. Any calculations and rough work can be done on the back side of the test pages. You will lose five points for not writing your name.

1. [6 pt] We discussed the use of `fftw_plan` type of variables to define the Fourier transform application. For a one-dimensional signal of size n, the plan was defined as

   ```
   int dim[] = {n};
   fftw_plan_dft ( 1, dim, fft_buf, fft_buf, FFTW_FORWARD, FFTW_ESTIMATE);
   ```
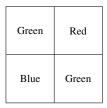
   I want you to write the plan definition for a color image of size $(M \times N)$. How will you write it if the image is a standard color image with pixel-wise layout as: $RGBRGBRGB \ldots RGB$? How will it be written if the layout of the image is in terms of red, green, and blue planes, given by $RRR \ldots RGGG \ldots GBBB \ldots B$?

2. [10 pt] An 8-bit color RGB image is represented by using 3 bits for red, 2 bits for green, and 3 bit for blue. How many different shades of gray can this system represent?

3. [6 pt] Show that the ideal low-pass filter is a zero phase shift filter.

4. [6 pt] How can you determine the quantity of noise parameters in a sensor?

5. [8 pt] What filter will you use to restore an imge corrupted by the following types of noise? Give a reason as to why your filter is appropriate for the type of noise.

   (a) Periodic noise

   (b) Uniform noise

   (c) Gaussian noise

   (d) Salt and pepper noise

6. [9+6 pt] Consider the follwoing 500×500 pixel RGB image, in which the squares are fully saturated red, green, and blue, and each of the colors is at maximum intensity [for xample, (1,0,0) for the red square]. An HSI image is generated from this image.

Green	Red
Blue	Green

(a) Describe the appearance of each HSI component image.

(b) The saturation component of the HSI image is smoothed using an averaging mask of size 125×125. Describe the appearance of the result (you may ignore image border effects in the filtering operation).