ELEN 6420 - Fourier Optics
Homework Assignment #5
Due Nov. 21 by 5pm

Problem 1

For this problem, you must go into the lab and do some experimentation with an existing hologram. You can do this part with your project group. The purpose of this question is to have you understand parallax. The hologram is of a chess board. Examine the virtual image closely. Notice that objects in the foreground can occlude objects in the background. This is full parallax. Now, use screens consisting of vertical, horizontal, and square openings to illuminate only a portion of the hologram. Re-examine the virtual image. Discuss what you see and why it occurs.

Problem 2

The Matlab beam propagation code is used for this problem. Use the interference between a “reference” Gaussian beam and another “object” beam that contains spatial information to create various types of holograms. There are four types you should study: thin amplitude hologram, thin phase hologram, thick amplitude, and thick phase. Start off with the two beams well separated but tilted so that intersection occurs in the hologram plane. Assume that the amplitude or phase transmittance of the hologram is proportional to the intensity, where the amplitude ranges from 0 to 1, and the phase from 0 to $2\pi$. Recording for the thin holograms is straightforward. After recording, use the reference beam to read out the hologram. Discuss your results.

Recording for the thick holograms is somewhat more involved. You must divide the medium into thin slices. Each slice is recorded sequentially, but you must take into account the propagation of the interfering beams through all prior slices. Again, use the reference wave to read out the hologram and discuss your results. What happens when you change the angle of the reference? The thickness of the hologram is your choice, but make sure it satisfies the thick hologram condition.

If you want to simplify your life on these problems, you may perform the simulations in 1-D rather than in 2-D.

Problem 3

Consider recording a hologram between an object and reference wave that have slightly different frequencies, say $\nu_r$ and $\nu_o$, with difference frequency $\delta \nu = |\nu_r - \nu_o|$. Now, assume that the exposure time of the hologram is $T$. Derive an expression for the hologram transmission function. What is the relative efficiency of the hologram as a function of $\delta \nu$, compared to the case when $\delta \nu = 0$? What might be the uses for this arrangement?