

MAS450 Spring 2003 Problem Set #2

Due: Lecture 8 at the end of class

MIT Students only: if you have not yet done so, take the online safety tests required by MIT.

More information can be found on the lab safety web page:

<http://www.spl.harvard.edu/courses/mas450/lab-safety/safety-guide.html>

You should finish this quiz, print your score sheet, and turn it in with either problem set #1 or #2.

Remember to pay attention to proper use of significant figures. This problem set requires plenty of calculation: it's designed to make you comfortable with several of holography's fundamental equations. Show your work everywhere.

1. A diffraction grating with a constant spatial frequency of 750 cycles/mm is struck by an illuminating ray of HeNe laser light at an angle of -27.5 degrees to the grating's surface normal.
 - a. (2pts) Sketch the setup.
 - b. (5pts) Calculate and sketch the output angle of all diffracted orders. In addition, calculate the deflection angle of each order (the angle between each output ray and zero order ray). Show your work.
 - c. (5pts) Assume the source is now trichromatic, with the additional wavelengths being 470nm and 540nm. Calculate and draw the diffracted orders for $m=+1$ only.
 - d. (3pts) Write a sentence summarizing what you think is most important about what you found in (b) and (c).
2. (6pts) A diffraction grating is made in HeNe laser light by two rays striking a holographic plate at 10. degrees (the "object" source) and $-20.$ degrees (the "reference" source) to the plate normal. The angles are measured using our standard angle conventions.
 - a. (2pts) Sketch the setup.
 - b. (3pts) Calculate the spatial frequency in cycles/mm.
 - c. (4pts) We wish to illuminate the plate in 543 nm light so that the $m=+2$ order plays out on axis (i.e., leaves the plate at an angle parallel to the surface normal). At what angle must we illuminate the plate? Sketch the rays.
3. A flat holographic optical element is formed by two mutually coherent, in-line, on-axis diverging point sources of HeNe laser light. The HOE is located at $z=0$. The reference source is located at $z=-1000$ mm, while the object source is located at $z=-250$ mm. The optical element is illuminated with a monochromatic source, in-line with the exposing sources and also on-axis, with a wavelength of 560nm and located at $z=-750$ mm.
 - a. (2pts) Sketch the layout.
 - b. (6pts) Using analytic ray tracing through a point on the holographic optical element located at $x=10$ and another point of your choosing, find where the positive and negative 1st and 2nd orders are focused. Show your work and sketch your results.
 - c. (5pts) Use the lens equation ($1/R$ equation) to confirm your results. Show your work.
 - d. (2pts) Estimate where the positive and negative 3rd and higher orders would be located (sketch, don't calculate).
 - e. (3pts) Where would a viewer be located in order to see all of the focused points? Sketch the viewer's location and roughly what the viewer would see.