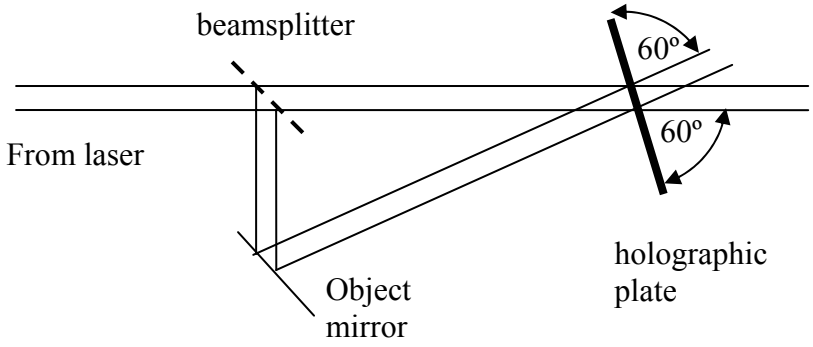
OPTICS, 114210 - Homework Exercises

G. Holography

1. Answer this question in two dimensions (x, y) using the paraxial approximation (small angles).

A hologram of a point object at position (-D, 0) is formed using light of wavelength λ_0 when the holographic plate is in the plane x=0, and the reference wave is a plane wave propagating parallel to the x-axis. After developing, the hologram is replaced in the plane x=0. What are the positions of the two holographic images
(a) when the reconstruction reference wave is the same as the original one,
(b) if the reference wave is tilted to small angle α to the x-axis,
(c) if the reference wave is parallel to the x-axis but is changed in wavelength to λ_1 ,
(d) if the reference wave is replaced by a spherical wave diverging from the point (-L, 0), and has wavelength λ_0 ?

2. A hologram of a plane mirror is formed as shown below. The object wave and the reference wave intersect at angle 60º and the wavelength is λ.
(a) what is the spacing between the interference fringes on the plate?
(b) If the hologram is developed and returned to its place, and in the meantime the mirror object has rotated by a small angle θ in the plane of the figure, what will be observed when looking through the hologram? (Take care not to look directly into the laser!)



3. A holographic focusing diffraction grating is made by interfering two coherent waves of wavelength λ_0. One is a plane wave traveling along the x-axis and the second is a spherical wave originating from a point source at position (-R, h). The interference pattern is photographed on a plate in the plane x=0. If the centre of the plate has a period $p\lambda_0$, where p is approximately 2, what is the value of R/h. The plate focuses the transmitted or reflected light to a point. Where is that point? If the dimensions of the plate are 5000 λ_0, what is the resolving power of the grating? If a photographic plate or CCD surface is to be in focus for all wavelengths (not only for λ_0), at what angle to the x-axis must it be placed?

4. A binary reflection hologram is produced by chemical etching of a reflective surface selectively to depth h (i.e. the depth is either 0 or h, but nothing else). What is the optimum depth h? What is the maximum diffraction efficiency of such a hologram?

5. A ternary reflection hologram is produced by chemical etching of a reflective surface selectively to depth either 0, h or 2h. Describe how a blazed hologram could be formed this way. What is the optimum depth h? What is the maximum diffraction efficiency of such a hologram in one order?