

# Holography

Holography is generally thought of as "three-dimensional photography." In this lab, you will produce a hologram that generates a 3-D image of a complex object of your choosing. You will also make a holographic grating, which is not only an interesting device in its own right, but also gives you the opportunity to predict mathematically the characteristics of a simple hologram and test the results quantitatively.

## Before you come to lab

Review the theory behind interfering plane waves. You will use this mathematics to predict the nodal spacing from the angle between waves and the wavelength of light. It is this prediction which you will compare to the measured result.

### I) Film Handling Procedures

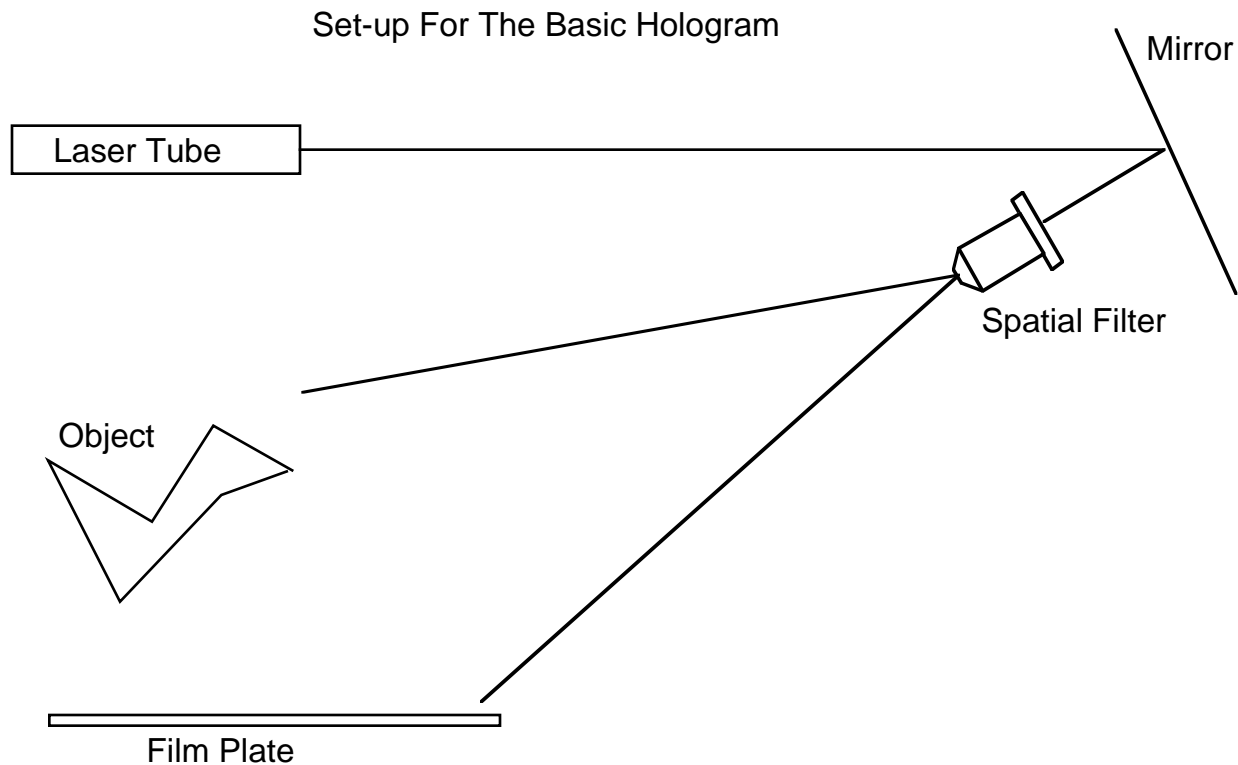
The procedure is the same in the two cases except for the layout of the optical system that illuminates the photographic plate. You should practice putting an exposed plate into the plate holder so you will be able to do it correctly with the unexposed plate because the plates must be handled in complete darkness until they have been processed. When you are sure that you have the optical system set up correctly (as described below), put an unexposed plate in the plateholder. The plastic box containing the unexposed plates is opened by pulling out on the tabs at the ends and pulling the top half up and off. After taking out a plate, push the top of the box down until you hear both of the tabs click. Be sure the room is dark when you open the box; exposing a box of these plates is an expensive mistake. The emulsion side of the plate (the one that feels tacky to a moist finger) must face the incoming light. The plate should be exposed for about 10 seconds. Be careful not to touch or disturb the optical table during or shortly before the exposure. For example, don't lift a beam stop off the table.

The plates should be developed for about 6 minutes in D-19 developer, rinsed in water for about 30 seconds, fixed for about 4 minutes in Rapid Fixer, and washed for about 5 minutes in running water. As we gain experience with the developing process, we will note any changes in this procedure on the blackboard in the holography room. The lights can be turned on after the plate has been in the fixer for about one minute. The darkroom timer should not face the plate during processing since the luminous dial could fog the plate. When you are finished processing your last hologram, throw out the developer in the tray, return the fixer to its bottle, wash out the trays, and carefully clean up the counter surface.

After the plate is dry, put it back in the holder on the optical table and you should be able to see the reconstructed image when the hologram is illuminated by the laser. What should the "image" in the holographic grating look like?

## II) The Basic Hologram

All the mirrors, microscope objectives, spatial filters, and the laser should be available on the optical bench, though you may need to move them around to set up your experiments. See the diagram below. A swan is provided as the object to be photographed, but other objects can be used as well. In selecting objects, remember that the object will be illuminated from the side, so a massive object will be mostly shadow, and rather uninteresting.



## II) The Holographic Grating

A diffraction grating can be made by exposing a fine-grained photographic plate to the interference pattern produced by two beams of light. There are several geometries which can be used for this, and they are illustrated on the following pages. Be very careful not to touch any optical surfaces. Try to get the two beams that illuminate the plate to have roughly the same intensity. This results in two (nearly) plane waves illuminating the film, and so there should be interference between them which produces nodal lines (as discussed in class). Because of this, the plate, when developed, will have a series of lines on it. Based on the mathematics of interfering plane waves, you should derive the line spacing of this grating. Refer to your lecture notes or see the American Journal of Physics, 55, 1015 (1987) for help on the theory if needed.

After the grating has been developed, you can experimentally measure the line spacing by shooting a laser beam through the grating and observing the angle between the undeflected

beam and the diffracted beam. For a diffraction grating, the relationship between the angle ( $\theta$ ) between the two beams and the fringe spacing ( $d$ ) is

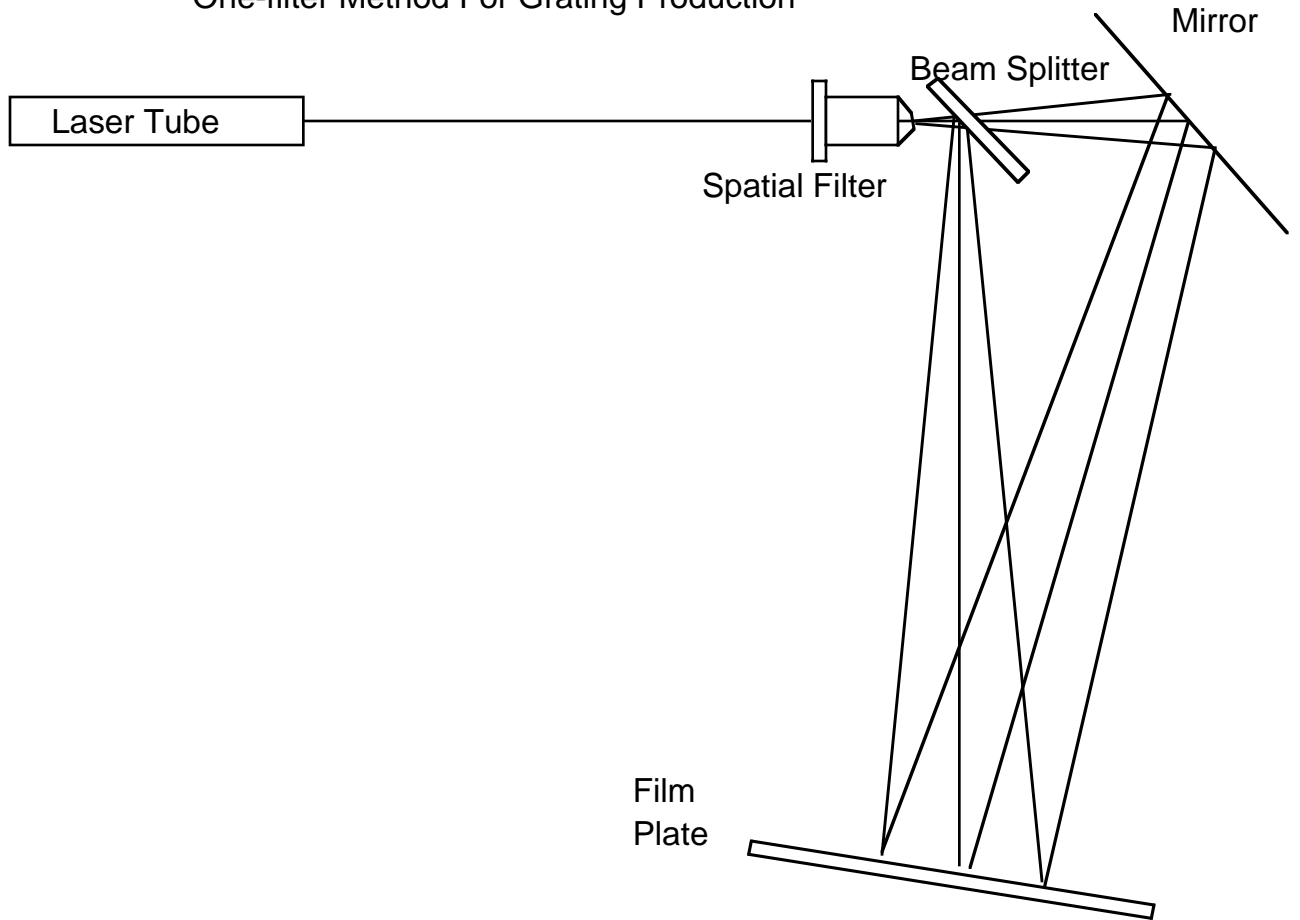
$$d = \frac{n\lambda}{\sin(\theta)}$$

This is not the formula used to predict the spacing based on the angle between the two interfering beams. It is the formula relating the spacing to the angles at which beams are produced. You should be able to derive this formula. The film plates are expensive (~\$8 each), so be careful in using them. It should be possible to complete this lab without wasting any plates. Please clean up when finished.

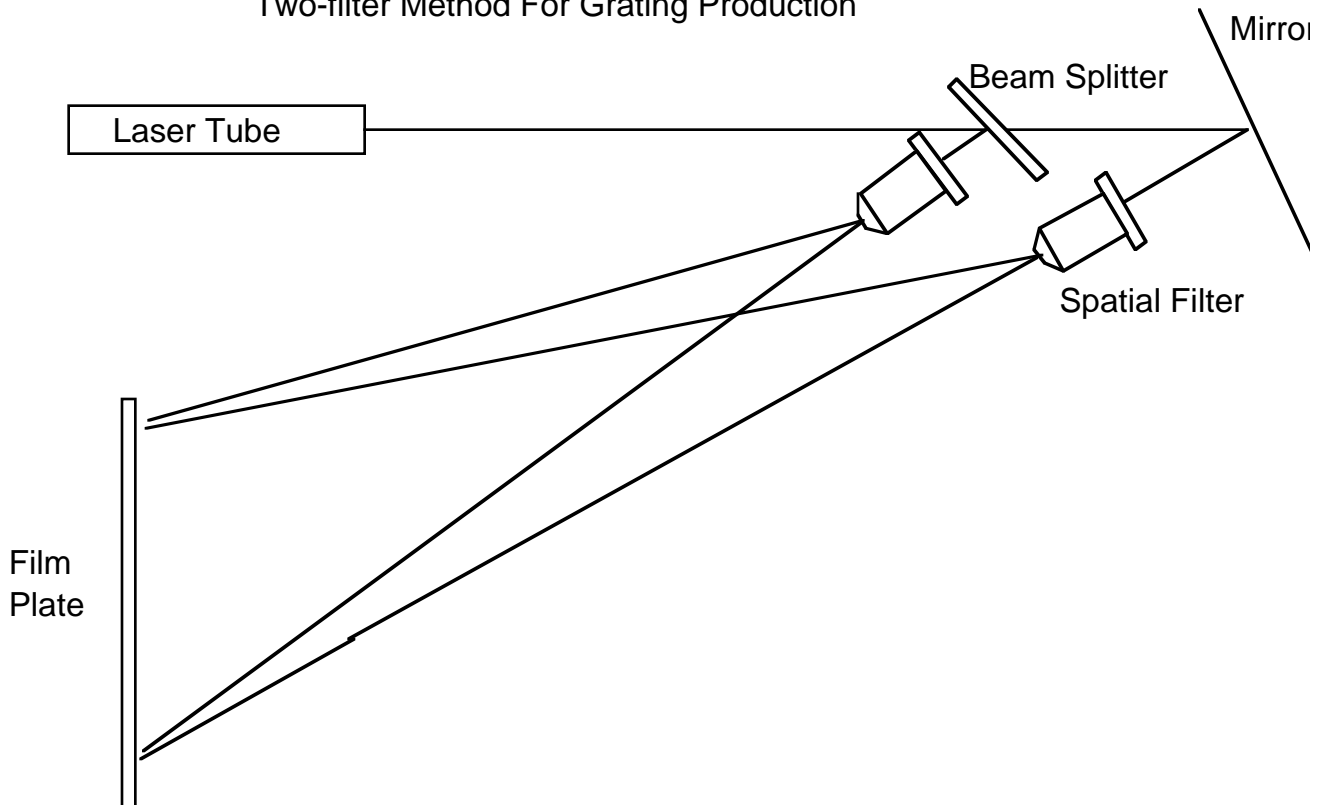
If you're interested, do the swan hologram second, and leave the swan in place. When you replace the processed plate in its holder and look for the swan, you will see a superposition of the real swan and the image swan. Slight pressures on the real swan should deform it so that the real and image swans produce interference fringes.

R.R.C.	4/15/87
S.J.H. rev.	1/16/91
C.E.C. rev.	5/19/95

### One-filter Method For Grating Production



### Two-filter Method For Grating Production



Method Used In AJP Reference For Grating Production

