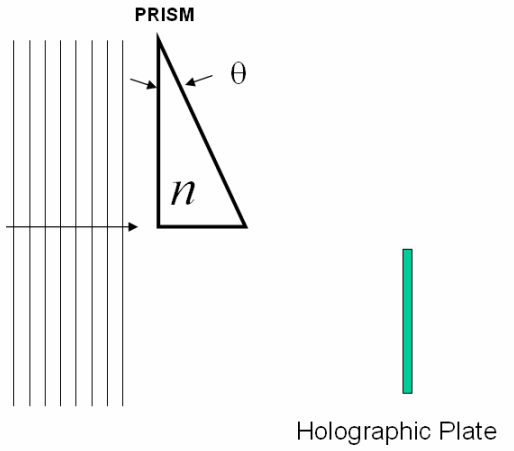
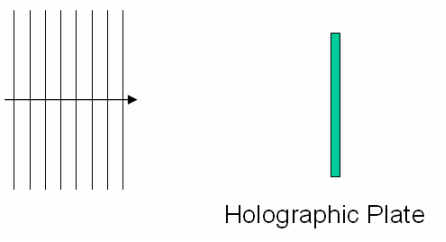
H-A1) A λ = 488 nm collimated plane wave illuminates a prism as shown in A below. The apex angle of the prism θ = 30 degrees. Part of the beam is refracted by the prism, which has refractive index n = 1.532. A thin, amplitude-type holographic plate is placed in the overlap region of the two beams. A hologram is recorded, and a λ = 633 nm plane-wave reconstruction beam is used to illuminate the processed hologram, where the reconstruction geometry is shown in B below. Describe the angular orientation of the beams that result from transmission through the hologram. State any assumptions that you make.



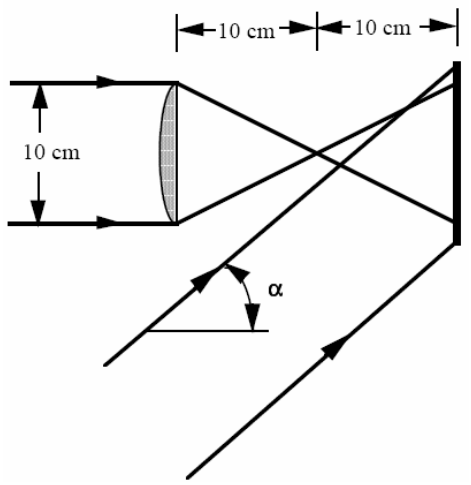
A. Exposure



B. Reconstruction

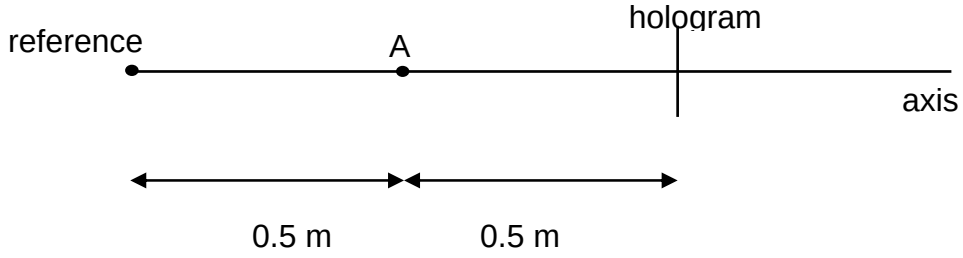
H-A2) A hologram of a spherical wave is made using the geometry shown below. If film non-linearities are neglected,

a) What is the minimum reference angle (α_{min}) to insure separation of the zero and first orders?
b) Why can self-interference terms be neglected?



H-A3) The geometries below are used to expose holograms, where transmission during reconstruction is proportional to irradiance during the recording step. The reference and object points can be considered perfect spherical sources. The recording wavelength is 0.4 μm.

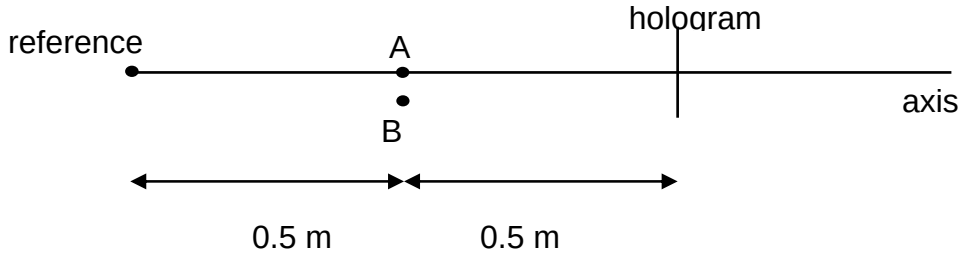
a.) Consider the hologram as a zone plate that is formed by the interference pattern generated between the reference point source and point source A during exposure. If the points are on axis, what are the primary focal lengths (+/-1 orders) of the zone plate generated with z1 as the distance from the reference to the hologram and z2 as the distance from point A to the hologram? (These focal lengths help to describe the real and virtual images during reconstruction.)



b.) Sketch the positions of the real and virtual images during reconstruction if the zone-plate hologram is replaced exactly in its original position after development and the reference source is not moved. During reconstruction, point A is removed.

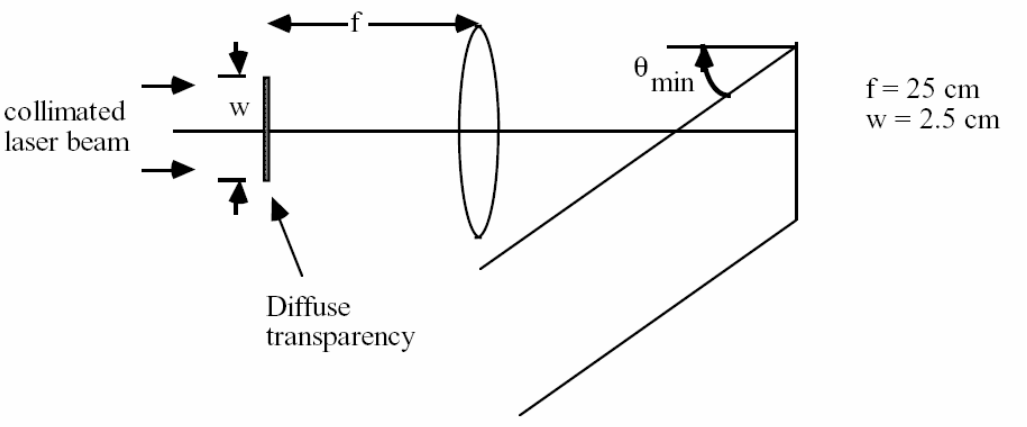
c.) Using your result in part (a), sketch the positions of the real and virtual images during reconstruction if the reference point is moved to an additional 1 m from the hologram after development. (That is, the geometry in the figure above is used for the recording, but the geometry for reconstruction contains only the reference point 2 m from the hologram.)

d.) Now, off-axis source point B is added to the geometry during exposure, as shown below. Point B is 1 cm from the axis. Sketch the positions of the real and virtual images during reconstruction if the zone-plate hologram is replaced exactly in its original position after development and the reference source is not moved. During reconstruction, points A and B are removed.



H-A4) A hologram is made using the geometry shown below. What is the minimum reference angle (θmin) to insure separation of orders if

a) the self-interference term can be neglected; and
b) the self-interference term can not be neglected? Neglect effects of film non-linearity.

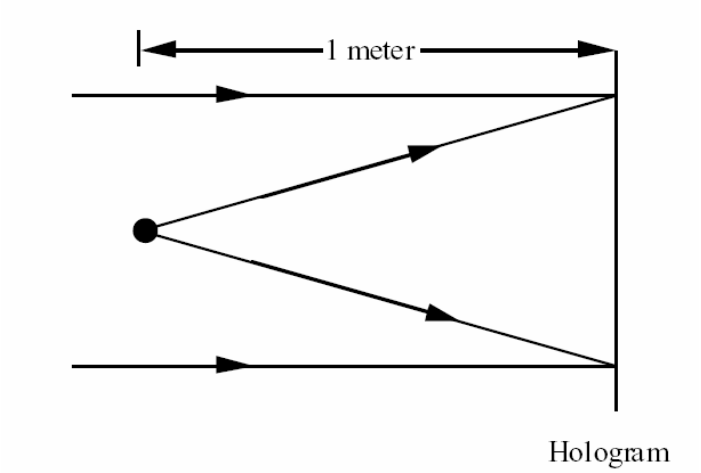


H-A5) A hologram is produced using a spherical wave of 50 cm radius of curvature for the object wave (x, y, z coordinates of 0, 10, -50) and a spherical wave of 50 cm radius of curvature for the reference wave (x, y, z coordinates of 0, -10, -50). The wavelength is 633 nm. The reconstructing wavefront is a spherical wave of 25 cm radius of curvature (x, y, z coordinates of 0, 0, -25) and 633 nm wavelength.

a) What is the shape of the interference fringes making up the hologram?
b) Give the x,y,z coordinates of the primary and conjugate images.

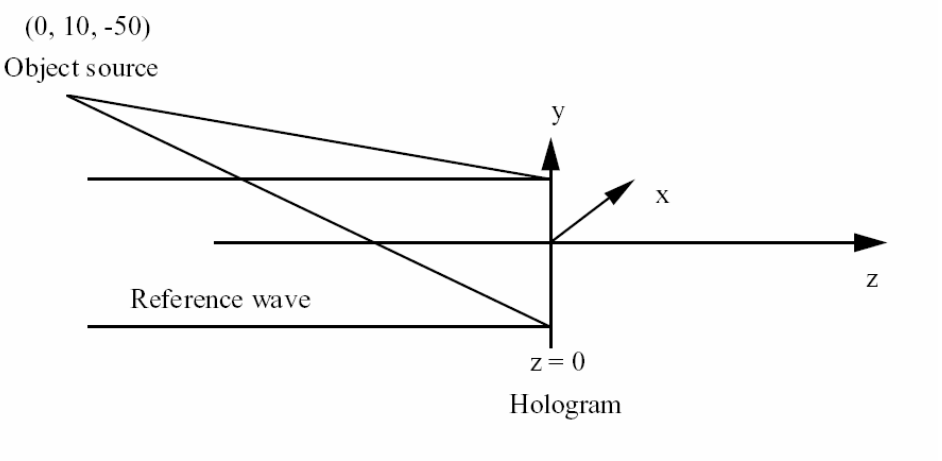
H-A6) A hologram is made using the setup shown below with a wavelength of 633 nm.

a) If the reconstruction wavelength is 500 nm, where will the primary and conjugate orders be focused?
b) If the reconstruction wavelength is 633 nm, where will the primary and conjugate orders be focused if the hologram is illuminated with a diverging spherical wave having a 1.5 meter radius of curvature?
c) What would you do in the reconstruction process to separate the zero, primary, and conjugate orders? Comment on the self-interference terms.

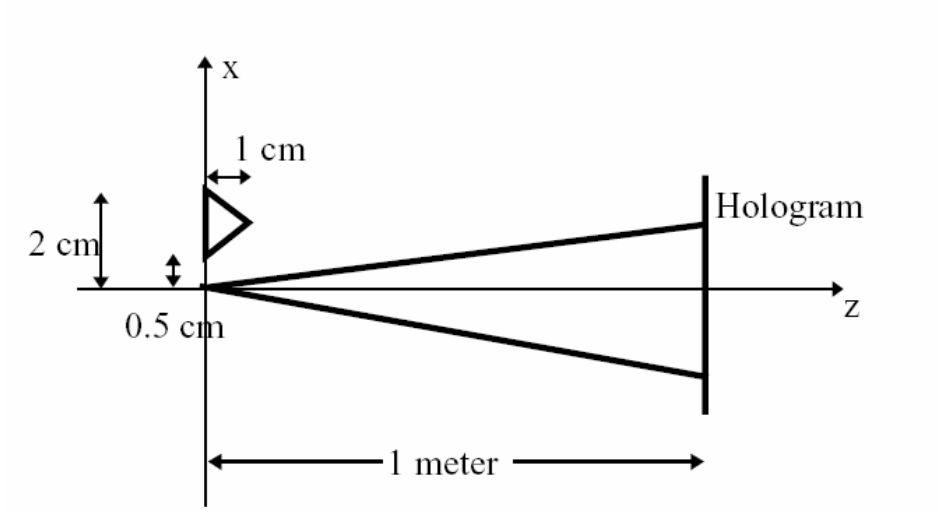


H-A7) A hologram is produced using a spherical wave of 50 cm radius of curvature for the object wave (x, y, z coordinates of 0, 10, -50) and a collimated plane wave incident at normal incidence for the reference wave. The wavelength is 633 nm. The reconstructing wavefront is also a plane wave at normal incidence and 633 nm wavelength.

a) Give the x,y,z coordinates of the primary and conjugate images.
b) Where are the self interference terms located?

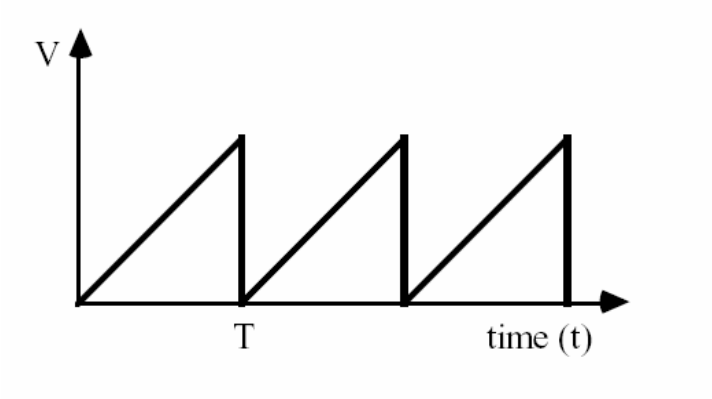


H-A8) A hologram is made by interfering a point source and a triangular shaped object as shown below. The hologram is reconstructed using a point source 0.5 m from the hologram. Give the x and z coordinates of the primary and conjugate images. Give a sketch to show what the images look like.



H-A9) Holographic interferometry is useful for measurement of deformations. Can the surfaces of the objects be rough compared to the wavelength of the light used? Explain.

H-A10) I am using holography to measure the vibration properties of the speakers used in my stereo. The waveform shown below is used to drive the speakers. Assume that the speakers follow the drive signal exactly with a response R(x,y) such that the displacement of the speaker cone is R(x,y)V. Assume the period of the waveform, T, is 10^{-3} second, the exposure time is one second and the photographic process is linear. Give the relative intensity of the hologram reconstruction for two points where RV=(wavelength)/4 and RV=3(wavelength)/2.

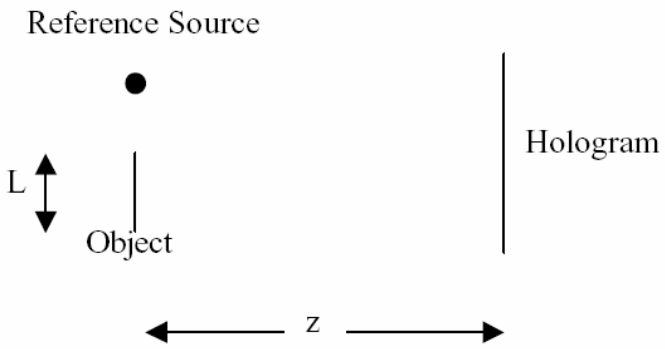


H-A11) We have a phase transmission grating produced by interfering two plane waves. The grating planes are perpendicular to the surface of the grating. The grating has an average refractive index of 1.52, a thickness of 15 microns, and a grating spacing of 1 micron. The hologram is illuminated with radiation having a wavelength of 514.5 nm.

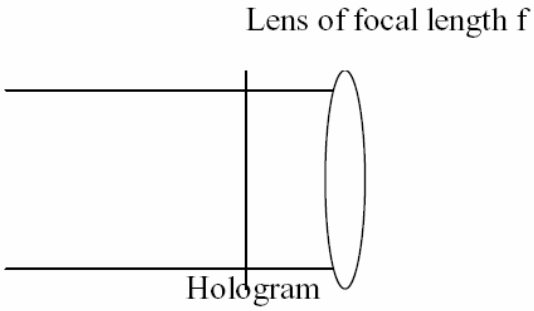
a) At what angles, measured outside of the hologram, can a plane wave be incident such that the relative diffraction efficiency is greater than or equal to 50%? (Neglect surface reflections.)
b) Repeat part a for a hologram thickness of 10 microns.

H-A12) A hologram is made by interfering light from a point source and light from a diffuse transparency of width L as shown below. The distance from the object to the recording plane is z. Assume a linear recording process. The reconstruction wavelength is the same as the recording wavelength. The images are obtained by illuminating the hologram with a plane wave, followed by a positive lens of focal length f.

a) What are the positions of the two first-order images relative to the lens?
b) What is the transverse magnification of the two first-order images?
c) How far from the center of the object transparency should the reference point source be placed in order to assure no overlap of the zero-order light with the first order images?



Hologram Recording



Hologram Reconstruction