Optics 505
Final Exam

May 13, 1999

2 hour, closed book, no notes, in class, exam

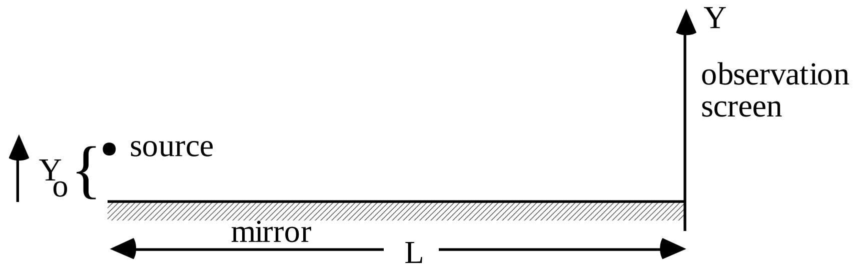
1) A linearly polarized source is used with a Young's two-pinhole interferometer. The wavelength of the light source is 500 nm and the two pinholes are separated a distance of 2 mm. The same amount of light is transmitted through each pinhole. A half-wave plate is placed over one pinhole. The fast axis of the half-wave plate makes an angle θ with respect to the direction of polarization of the light incident upon the half-wave plate. A perfect polarizer is placed in the output of the interferometer. The transmission axis of the polarizer is in the direction of polarization of the light coming from the pinhole without the half-wave plate.

    a) (5 Pts) What is the spacing of the interference fringes observed on an observation screen placed 1 meter from the two pinholes?

    b) (5 Pts) What is the fringe visibility as a function of θ?

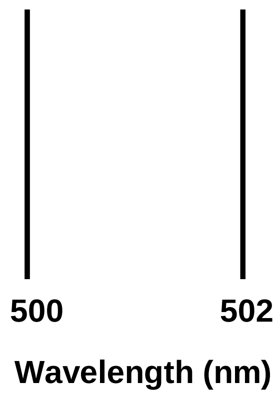
    c) (10 Pts) Assume the polarizer is non-perfect in that it transmits 95% of the light having a polarization along the transmission axis of the polarizer and 5% of the light having the orthogonal polarization. What is the observed fringe visibility as a function of θ?

2) (10 Pts) Using Lloyd's mirror, interference fringes are observed on a screen a distance L = 1 meter from the source. Assume the reflectance of the mirror to be unity and assume no phase change upon reflection. If the light source has two wavelengths, 550 nm and 560 nm, and they have equal brightness, how many bright fringes do we have for the 560 nm wavelength before the fringe visibility drops to zero if Y_o = 1 mm?



3) The following two fringes were obtained using a FECO to test two flat mirrors. Assume there is zero phase change upon reflection.

   a) (5 Pts) What is the order number for the left fringe?
   b) (5 Pts) What is the separation between the two mirrors?
   c) (5 Pts) How would the fringe spacing change if the mirror separation were doubled?



4) A Fresnel zone plate has a focal length of 20 cm for a wavelength of 600 nm.

   a) (5 Pts) What is the diameter of the first Fresnel zone making up the Fresnel Zone plate?

   b) (5 Pts) The zone plate is illuminated with a spherical wave of wavelength 500 nm coming from a source 20 cm to the left of the plate. Where do the two first orders come to focus?

   c) (5 Pts) All Fresnel zones in the Fresnel Zone plate transmit 100 % of the incident light, however every other Fresnel zone is covered with a thin film that introduces a phase change of ϕ radians. Give an expression for the amount of light in the first order relative to the amount of light in the first order of a conventional zone plate for which every other Fresnel zone is opaque.

5) A 200 line/mm, 2-cm square diffraction transmission grating is illuminated at normal incidence with a plane wave. The diffraction pattern is observed in the focal plane of a 10 cm focal length lens.

a) (10 Pts) What angle, in degrees, does the 4^{th} diffraction order leave the grating for a wavelength of 500 nm? What is the physical distance between the zero and 4^{th} order in the observation plane in the focal plane of the 10 cm focal length lens?

b) (5 Pts) What is the minimum resolvable wavelength difference in the third order for a wavelength of approximately 500 nm?

6) A 20 mm diameter lens having a 200 mm focal length operating at a wavelength of 500 nm is used to image a target that is 400 mm from the lens.

a) (5 Pts) Assuming no aberration, what is the cutoff frequency of the modulation transfer function?

b) (5 Pts) What is the cutoff frequency if the lens has 2 waves of third-order spherical aberration?

c) (5 Pts) What is the cutoff frequency if the lens has no aberration, but it does have a 4 mm diameter central obscuration?

7) (10 Pts) What is the maximum spatial frequency of the speckles obtained in the following setup if the wavelength is 500 nm? State any assumptions being made.