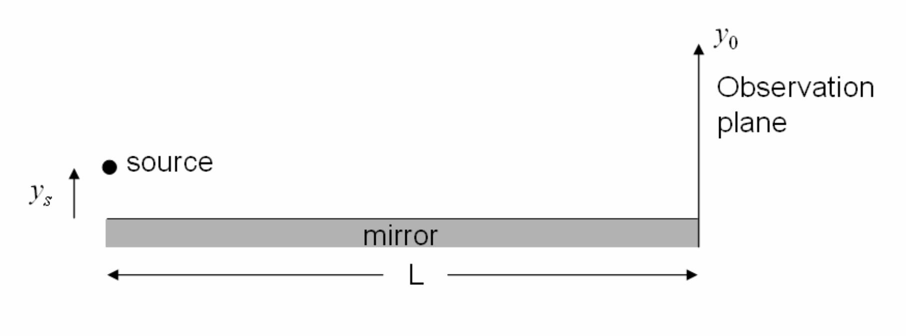
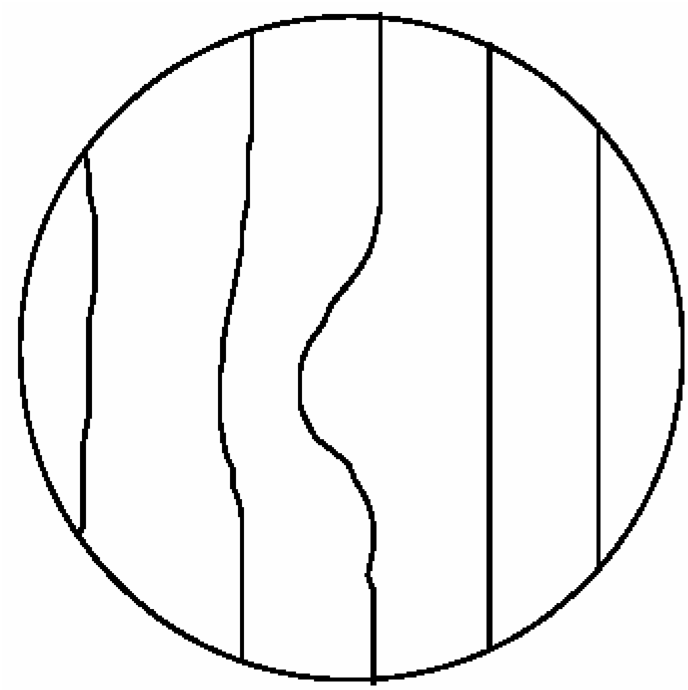
I-A1) Using Lloyd's mirror, interference fringes are observed on a plane a distance L from the source. Assume y_s<<L and y_0 <<L. Assume the reflectance of the mirror to be unity. If the point source has a power spectrum $g(v)$, how does the irradiance distribution on the observation screen depend upon $g(v)$?



I-A2) Using Lloyd's mirror, as shown in I-A1, interference fringes are observed on a screen a distance L from the source. Assume the reflectance of the mirror to be unity. If the point source has a power spectrum $g(v)\text{step}(v)=\frac{1}{\Delta v}\text{rect}\left(\frac{v-\bar{v}}{\Delta v}\right)$, where $\bar{\lambda}$ = 650 nm, $\Delta\lambda$ = 30 nm, L = 100 mm and y_s = 0.5 mm, what the irradiance distribution on the observation screen?

I-A3) The following interferogram was obtained testing a nearly flat mirror in a Fizeau interferometer using a wavelength of 500 nm. When the right side of the reference surface is pressed downward toward the sample surface, the number of fringes in the interferogram increases.

a) What is the peak-valley error, in units of microns, of the mirror surface?
b) Is the center of the mirror a high point or a low point? Explain.



I-A4) A Fizeau interferometer is used to compare a spherical surface of 100m radius of curvature with a flat mirror. The flat mirror is 100mm in diameter and the spherical surface is 50 mm in diameter. The wavelength is 500nm. Let the two surfaces touch at the center of the spherical surface.

a) Is the center fringe bright or dark? Explain.
b) Let there be no tilt between the two surfaces so circular fringes are obtained. If the two surfaces touch in the center of the spherical mirror, how many bright circular fringes are obtained?
c) What angle will the flat mirror have to be tilted relative to the center of the spherical surface so there are no closed fringes?
d) The interferometer is again adjusted for circular fringes. Do the circular fringes collapse to the center or expand from the center if the spherical surface is moved away from the flat surface.

I-A5) Newton's fringes are observed with a quasi-monochromatic light of wavelength 500 nm. If the radius of curvature of the lens forming one part of the interfering system is 5 meters, what is the radius of the 25th bright fringe?

I-A6) A thin film of oil (n = 1.5) floats on a pool of water (n = 1.3). An observer looking at the oil film from near-normal incidence in sunlight notices straight-line, colored fringes on the film.

a.) What is the shape of the oil film?
b.) What is the maximum thickness of oil in which fringe modulation can be observed, if visible light extends from 400nm to 700nm.

I-A7) Show that for a plane parallel plate (Murty) lateral shear interferometer the shear, S, is given by

$$\frac{t \sin 2\theta}{\sqrt{n^2 - \sin^2 \theta}}$$

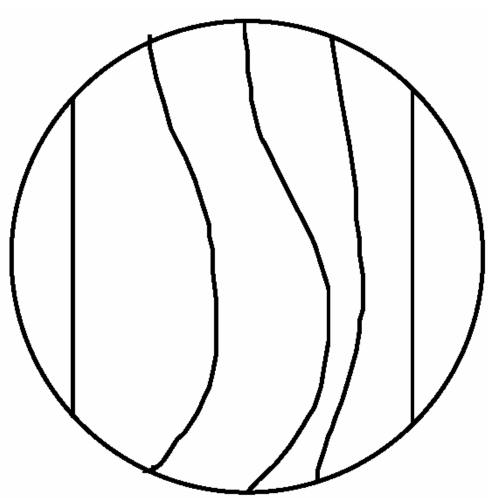
where t is the plate thickness, θ is the angle of incidence, and n is the refractive index.

I-A8) a) Where are the fringes localized in a Michelson interferometer if
i) I have circular fringes?
ii) I have essentially straight fringes?
b) I adjust a Michelson interferometer to have white light fringes. Are the fringes circular or straight? Explain.

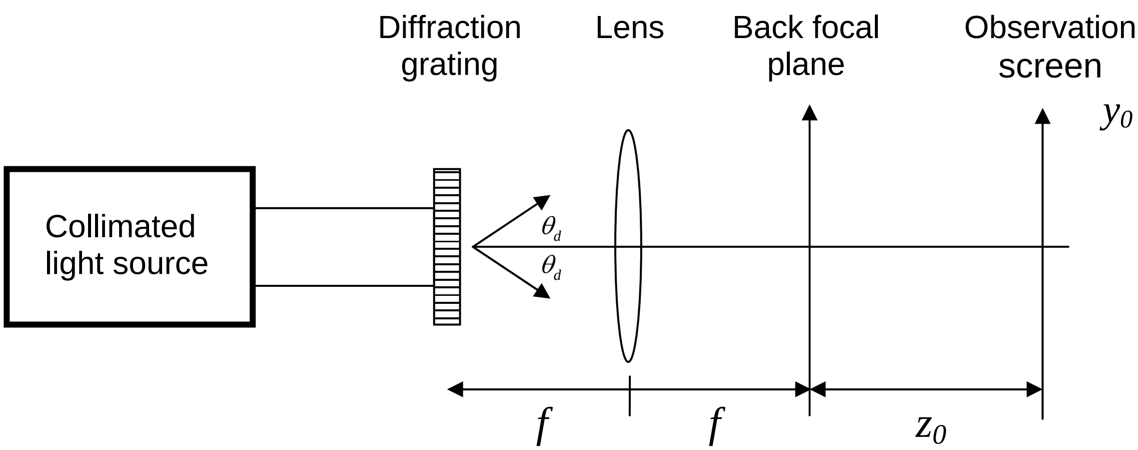
I-A9) Determine the functional form of the visibility for a Fresnel Biprism. Assume that the fringes are observed near the axis. The source is quasimonochromatic and extended. The visibility should be a function of the size of the source, distance of the observation plane from the prism, the separation of the conjugate images, and the source wavelength. State any assumptions you make.

I-A10) The following interferogram was obtained using a Twyman-Green to test in transmission a window having a refractive index of 1.5. The wavelength of the source is 633 nm.

a) What is the maximum thickness variation in units of microns in the window?
b) The same window is tested using a Mach-Zehnder interferometer. In 25 words or less, describe the difference between the Twyman-Green and the Mach-Zehnder interferograms.



I-A11) The system shown below is used to produce interference fringes in the observation plane. It consists of a collimated light source, a diffraction grating and a lens. The ideal diffraction grating produces two plane waves on transmission, with equal and opposite angles. NOTE: ONLY TWO diffracted orders are produced by the grating, which are at $\pm\theta_d$. There is no zero order or higher orders. The angles are given by $\sin\theta_d = \frac{\nu_g c}{\nu}$, where $\nu_g = 10^5$ m^{-1} is the spatial frequency of the grating (corresponding to a 100 line pairs per mm grating), $c = 3\text{x}10^8$ ms^{-1} is the speed of light in free space, and ν is the temporal frequency of the light source. Each plane wave forms a tiny spot in the back focus plane of the lens, which acts as a point source. By varying the wavelength, $\lambda = c/\nu$, the plane-wave angles and spot spacing change. The focal length of the lens is f = 100 mm. The distance from the back focus plane of the lens to the observation plane is z_0. You may assume that the distance $z_0 >> d$, where d is the spot spacing and the observation range in y_0 is small compared to z_0. Also, assume the small angle approximation for θ_d, where $\theta_d \approx \frac{\nu_g c}{\nu}$.



a.) (4 pts) Derive an expression for the fringe period Λ as a function of any necessary system parameters.

b.) (2 pts) What characteristics of the fringe pattern change with wavelength (such as shift, period)?

c.) (2 pts) Determine the fringe spacing for z_0 = 1 m and λ = 0.5 µm.

d.) (2 pts) Comment on whether or not it is possible to see fringes if collimated white light is used for the source.

I-A12) Compare and contrast Phase Stepping Interferometry with Vertical Scanning Interferometry. (300 words or less and no more than two figures.)

I-A13) Phase-shifting interferometry is used with a Twyman-Green interferometer.

a) Sketch the interferometer showing all the essential items required for performing phase stepping-interferometry.

b) What is the minimum number of phase steps required? Explain.

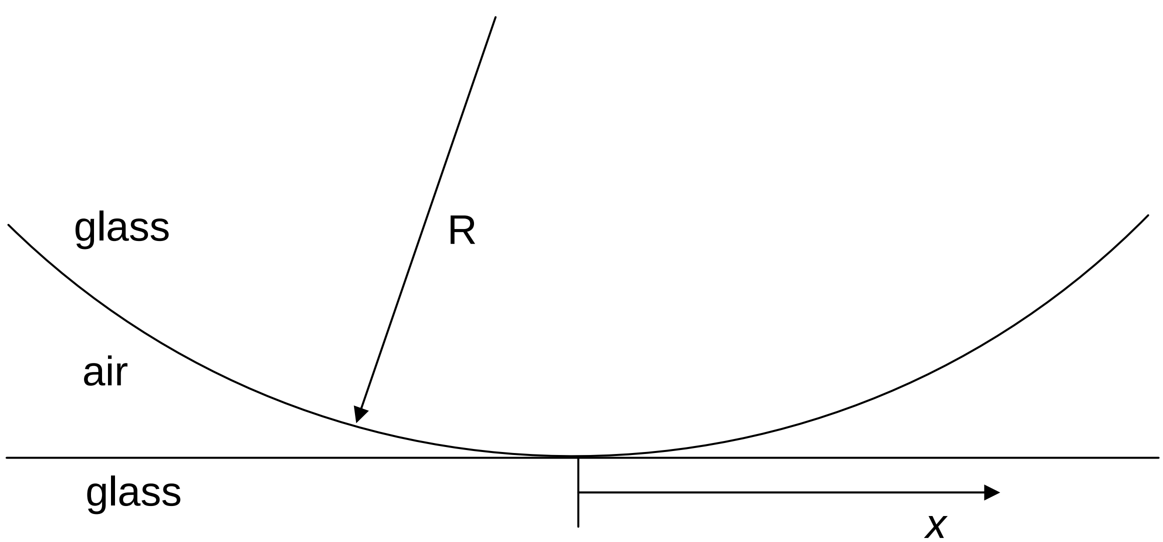
I-A14)

a) The integrating-bucket version of phase shifting interferometry is used with a Twyman-Green interferometer. How much is the contrast of the signal reduced if the detector integrates the light falling on it as the phase changes by 90 degrees?

b) Give an advantage of the integrated-bucket method over the phase-stepping method.

I-A15) A curved surface of radius R = 100 mm is placed on a flat glass plate as shown below. The Fizeau fringes are viewed at near normal incidence with a source of mean wavelength 600 nm. The fringes wash out, i.e. have their first region of zero visibility, at a radius x = 10 mm. Assume that the source has a power spectrum given by:

$$a^2(\nu) = \frac{1}{\Delta\nu}\,\mathrm{rect}\left(\frac{\nu - \bar{\nu}}{\Delta\nu}\right) \quad .$$

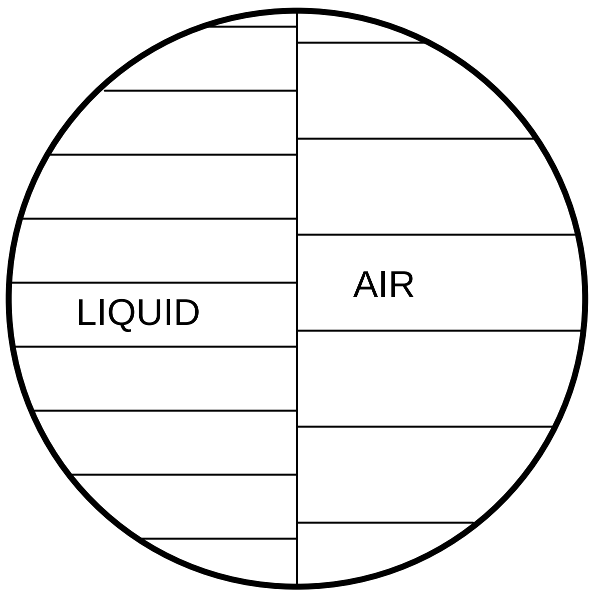


a.) What is the bandwidth $\Delta\nu$ of the source in Hz?

b.) What is the bandwidth $\Delta\lambda$ in nm that corresponds to (a)?

I-A16) Two perfect optical flats are used to produce a Fizeau film, which has a simple linear wedge running from the bottom of the film to the top of the film. Straight-line, equally spaced fringes are observed with air in the wedge when viewed with a quasimonochromatic source. An unknown liquid is inserted into the left half of the Fizeau plate, as shown below.

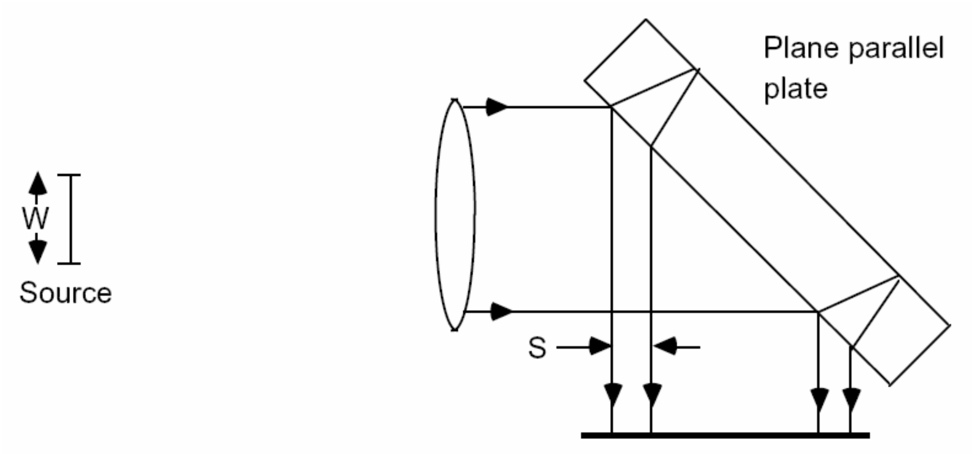
a.) How does the imaginary part of the liquid's refractive index influence the fringe spacing on the liquid side?
b.) What is the real part of the liquid's refractive index?



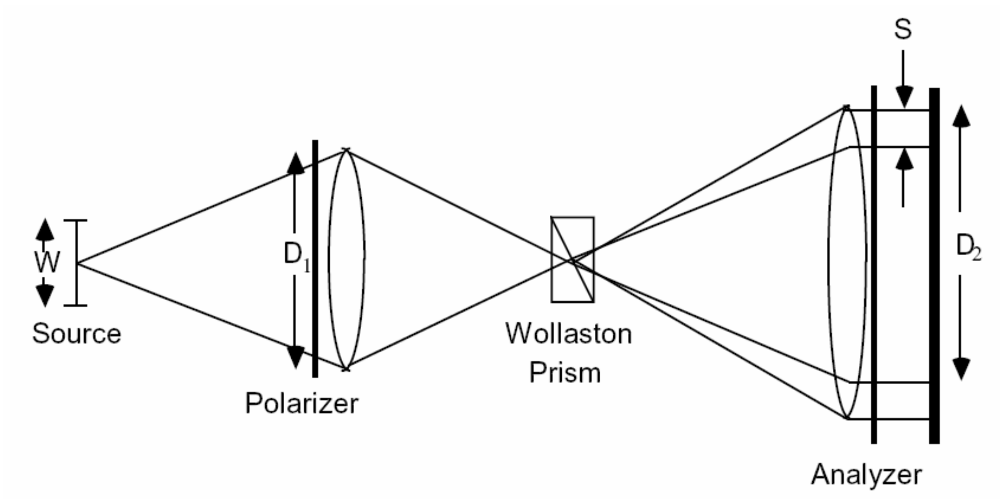
I-A17) A quasi-monochromatic extended source of wavelength λ is used in a lateral shear interferometer setup, as shown below. The source is square with a width W, the focal length of the lens is f, the lens diameter is D, and the shear is S. The interferometer is adjusted to give straight equi-spaced fringes.

a) Without changing the amount of relative shear, how would you adjust the interferometer setup to change the number of straight equi-spaced fringes?

b) If the extended source is replaced with a point source, unity visibility fringes are produced. In terms of λ, W, f, D, S, and any other pertinent quantities, what fringe visibility is obtained when the extended source is used in the interferometer? Assume the source size is small compared to f and D.



c.) Repeat (b) for the following setup.



I-A18) A plate having a wedge of 10 seconds of arc is used to check a 2 cm diameter helium neon laser beam for collimation. The plate produces a shear of 2mm. Let the plate have a refractive index of 1.5 and let it be oriented such that the shear is horizontal.

a) If collimated light is present, horizontal fringes are obtained. What is the spacing of the fringes?

b)If the beam incident upon the beam splitter has a radius of curvature of 100 meters, what angle, in degrees, will the fringes make with respect to the horizontal?

I-A19) A lateral shear interferometer produces a lateral shear given by

$$\vec{S} = a\hat{x} + b\hat{y}$$

Give an expression describing the loci of bright fringes if the phase distribution φ (x,y) of the wavefront under test is given by $\varphi(x,y)=A(x^2+y^2)$, where A is a constant.