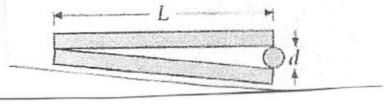
4C – Problem set 9: Interference

1. Two optically flat pieces of glass of length *L* are separated at one end by a wire of diameter *d* as shown. The setup is illuminated by monochromatic light of wavelength λ.

a. Is the first fringe bright or dark?

b. How many fringes are observed? (That is, what is the number m at the end of the glass?

c. How far apart are the fringes?



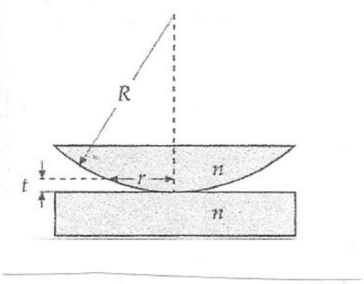
2. Considering the same apparatus as problem 1 shown above, suppose the upper plate is plastic and the index of refraction n_1, the wedge is filled with a silicone grease with an index of refraction $n_2 < n_1$ and the bottom plate is a dense flint glass with $n_3 > n_2$. What happens now? How far apart are the fringes?

3. Two narrow slits, separated by a distance *d*, are illuminated by a coherent monochromatic light source of wavelength λ. Their interference pattern is to be observed on a screen a large distance *L* away. (a) Find the spacing *y* of the maxima on the screen. (b) Calculate *y* if $d = 1$ cm, $L = 1$ m and $\lambda = 500$ nm. (c) How close together should the slits be placed for the maxima to be separated by 1mm?

4. A thin film with an index of refraction $n = 1.5$ is surrounded by air. It is illuminated normally by white light and is viewed by reflection. Analysis of the resulting reflected light shows that wavelengths 360, 450 and 600 nm are the only missing wavelengths in or near the visible portion of the spectrum. (a) What is the thickness of the film? (b) What visible wavelengths are brightest in the reflected interference pattern? (c) if this film were resting on glass with an index of refraction $n_g = 1.6$, what wavelengths in the visible spectrum would be missing?

5. A film of oil of index of refraction n floats on water with an index of refraction $n_w > n$. When illuminated with white light at normal incidence, light of wavelengths λ_1 and $\lambda_2 = \lambda_1 + \Delta\lambda$ is predominate in the reflected light. Determine the thickness of the film.

6. A Newton's-ring apparatus consists of a glass lens with a radius of curvature *R* that rests on a flat glass plate as shown. The thin film is air of variable thickness. The pattern is viewed by reflected light.



(a) Show that for a thickness *t* the condition for a bright (constructive interference) ring is

$$t = \left(m + \frac{1}{2}\right)\frac{\lambda}{2} \quad \text{m} = 0, 1, 2, \ldots$$

(b) Apply the Pythagorean theorem to the triangle of sides r, *R*- *t* and hypotenuse *R* to show that for t << *R*, the radius of a fringe is related to *t* by $r = \sqrt{2tR}$

(c) How would the transmitted pattern look in comparison with the reflected one?

(d) Use R = 10 m and a diameter of 4 cm for the lens. How many bright fringes would you see if the apparatus were illuminated by yellow sodium light (λ = 590 nm)and were viewed by reflection? (e)

What would be the diameter of the sixth bright fringe? (f) If the glass used in the apparatus has an index of refraction $n = 1.5$ and water ($n_w = 1.33$) is placed between the two pieces of glass, what change will take place in the bright fringes?

7. A source S of monochromatic light and a detector D are both located in air a distance h above a horizontal plane sheet of glass, and are separated by a horizontal distance x. Waves reaching D directly from S interfere with waves that reflect off the glass. The distance x is small compared to h so that the reflection is at close to normal incidence. Find the condition for constructive interference and the condition for destructive interference.

8. Two thin parallel slits are made in an opaque sheet of film. When a monochromatic beam of light is shone through them at normal incidence, the first bright fringes in the transmitted light occur in air at $\pm 18^\circ$. When the apparatus is immersed in a liquid, the same bright fringes now occur at $\pm 12.6^\circ$. Find the index of refraction of the liquid.

9. Red light with wavelength 700 nm is passed through a two silt apparatus. At the same time, monochromatic visible wlight with another wavelength passes through the same apparatus. As a result, most of the pattern that appears on the screen is mixture of two colors; however, the center of the third bright fringe ($m = 3$) of red light appears pure red, with none of the other color. What are the possible wavelengths of the second time of visible light? Do you need to know the slit spaceing to answer this question? Why or why not?

10. What is the thinnest film of a coating with $n = 1.42$ on glass ($n = 1.52$) for which destructive interference of the red component (650nm) of an incident white light beam in air can take place by reflection?