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3. [30 pts] Light of wavelength λ impinges upon two parallel slits whose width is 'a' and separation is 'd'. The diffraction pattern is projected onto a screen a distance 'L' away. Assume that the slit separation d>a, the distance to the screen is much larger than the slit spacing L>>d, 'a' is small enough to observe diffraction effects, and the entire apparatus is in air.

a) [8 pts] List all the ways one can cause the diffraction pattern maxima on the screen to move closer together. Make sure to explain your reasoning.

As because $L >> d$, we can work in small angle approximation and hence $\Delta Y = \frac{\lambda L}{d}$ (distance in screen between two consecutive maxima). Clearly then, to move the maxima closer we need to either

decrease λ or L

or, increase slit separation d.

b) [7 pts] What would happen to the diffraction pattern if the entire apparatus were to be submerged in an oil of index n? Explain your reasoning.

In a medium of higher refractive index speed of light is smaller by a factor of $1/n$ (n = refractive index). However, freq. is uneffected in the process and therefore wavelength decreases by the same factor. As suggested in part (a) then, the pattern of maxima will move closer on screen.

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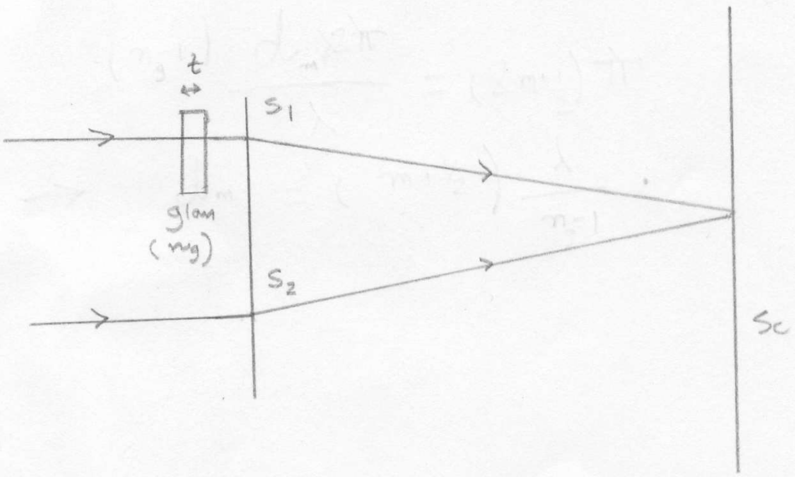
c) [15 pts] The aparatus is in air. Consider the middle of the central maximum on the screen (where the path length is the same for light emanating from both slits) and call it point P. A small glass plate of index n_g is then inserted directly behind ***one*** of the slits. Assume the thickness of the glass is very small compared to L (that is, assume that the rays of interest enter and leave the glass plate at approximately normal incidence). For what thickness of the glass plate does a minimum in the diffraction pattern ocurr at the central point P on the screen?



The extra phase difference that the glass slab introduce in the upper ray is $(n_g - 1) \cdot t \cdot \frac{2\pi}{\lambda_{air}}$ [page 690]. To have a minimum at the centre then one needs to have

$$(n_g - 1) \cdot \frac{2\pi t}{\lambda_{air}} = (2m+1)\pi, \text{ where } m = 0, 1, \dots$$

[condition of destructive interference of two rays]. Hence

$$t = \frac{(m + \frac{1}{2})\lambda_{air}}{(n_g - 1)}, \quad m = 0, 1, \dots$$