PROBLEM 1 – 15 points

[5 points] (a) A green laser beam (λ = 532 nm in air) is incident on a double slit, creating an interference pattern of bright and dark spots on a screen some distance away. **If you want the spots in the pattern to be closer together** (measuring the distance between spots as the distance between their centers) which of the following changes could you make? **Select all that apply.** Grading scheme: +1 for each correct choice; –1 for each incorrect choice. Negative scores will be given zero.

[ ] Replace the green laser by a red laser.

[ ] Replace the green laser by a violet laser.

[ ] Increase d, the distance between the two slits.

[ ] Decrease d, the distance between the two slits.

[ ] Increase the distance between the double slit and the screen.

[ ] Decrease the distance between the double slit and the screen.

[ ] Immerse the entire apparatus in water.

[ ] Immerse the entire apparatus in olive oil.

[ ] Replace the double slit by a diffraction grating, keeping d the same

[ ] Use a beam of electrons instead of a green laser, with the electrons having a de Broglie wavelength of 532 nm.

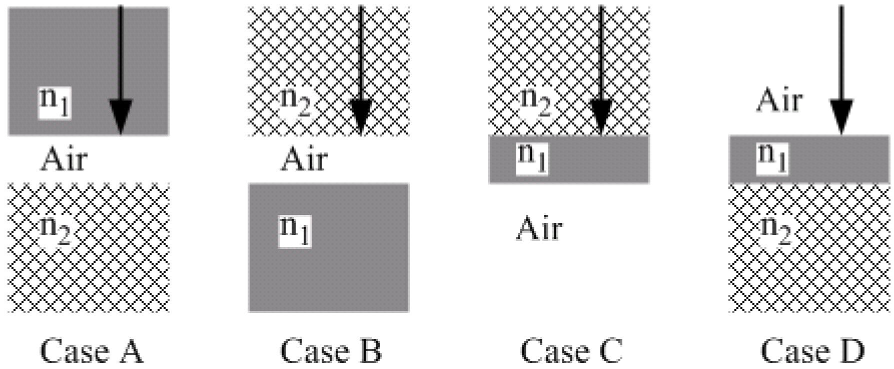
Now assume that the slits are separated by a distance of d = 5.32 $\times 10^{-5}$ m. A screen is placed 20 m away from the slits.
Remember that for small angles we can use the approximation $\theta \approx \sin\theta \approx \tan\theta$.

[5 points] (b) Find the spacing between the central maximum and one of the first-order maxima on the screen.

[5 points] (c) The entire apparatus is now immersed in a liquid that has an index of refraction n = 1.5. What is the new spacing between the central maximum and one of the first-order maxima on the screen?

PROBLEM 2 – 15 points

The diagram shows four situations in which light of wavelength λ is incident perpendicularly on a very thin layer (the middle layer in each case). The indicated indices of refraction are $n_1 = 1.50$ and $n_2 = 2.00$.



[8 points] (a) In each case, consider what happens to the reflected light in the limit where the thickness of the thin layer approaches zero.

(i) In case A, a thin-film thickness approaching zero causes the reflected light to be

[ ] eliminated by destructive interference [ ] bright by constructive interference

(ii) In case B, a thin-film thickness approaching zero causes the reflected light to be

[ ] eliminated by destructive interference [ ] bright by constructive interference

(iii) In case C, a thin-film thickness approaching zero causes the reflected light to be

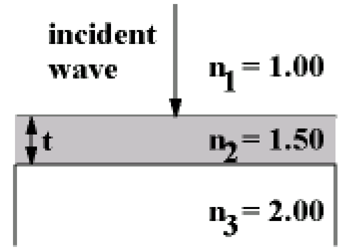
[ ] eliminated by destructive interference [ ] bright by constructive interference

(iv) In case D, a thin-film thickness approaching zero causes the reflected light to be

[ ] eliminated by destructive interference [ ] bright by constructive interference

[7 points] (b) In **case B**, what is the minimum **non-zero** thickness of the thin-film that would produce **destructive interference** for reflected light if the wavelength of the incident light is 600 nm (measured in air)?

PROBLEM 3 - 15 points



A thin piece of glass with an index of refraction of n = 1.50 is placed on top of a medium that has an index of refraction n = 2.00. A beam of light traveling in air (n = 1.00) shines perpendicularly down on the glass. The beam contains light of only two colors, blue light with a wavelength in air of 450 nm and orange light with a wavelength in air of 600 nm.

[5 points] (a) What is the minimum non-zero thickness of the glass that gives completely constructive interference for the blue light reflecting from the film?

[5 points] (b) What is the minimum non-zero thickness of the glass that gives completely constructive interference for the orange light reflecting from the film?

[5 points] (c) What is the minimum non-zero thickness of the glass that gives completely constructive interference for BOTH the blue and orange light simultaneously?