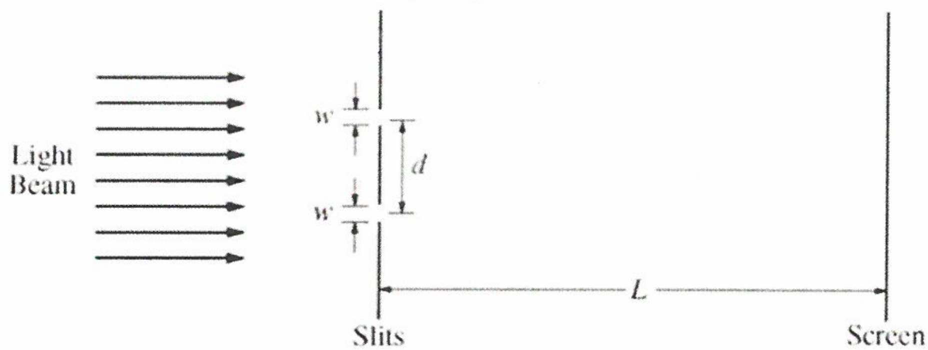
Wave Phenomena Exam Review

Directions – Complete the following problems to help prepare you for the upcoming test.

2009 AP® PHYSICS B FREE-RESPONSE QUESTIONS

6. (10 points)

In a classroom demonstration, a beam of coherent light of wavelength 550 nm is incident perpendicularly onto a pair of slits. Each slit has a width w of 1.2×10^{-6} m, and the distance d between the centers of the slits is 1.8×10^{-5} m. The class observes light and dark fringes on a screen that is a distance L of 2.2 m from the slits. Your notebook shows the following setup for the demonstration.



Note: Figure not drawn to scale.

(a) Calculate the frequency of the light.

(b) Calculate the distance between two adjacent dark fringes on the screen.

The entire apparatus is now immersed in a transparent fluid having index of refraction 1.4.

(c) What is the frequency of the light in the transparent fluid?

(d) Does the distance between the dark fringes increase, decrease, or remain the same?

____ Increase X Decrease ____ Remain the same

Explain your reasoning.

a) $f = \frac{v}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{550 \times 10^{-9} \text{ m}} = 5.45 \times 10^{14} \text{ Hz}$

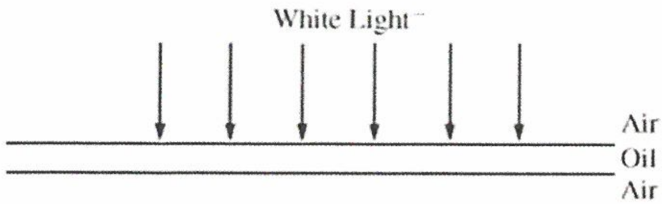
b) $x = \frac{m\lambda L}{d}$ $\Delta x = \frac{\Delta m \lambda L}{d} = \frac{(1)(550 \times 10^{-9}\text{m})(2.2\text{m})}{(1.8 \times 10^{-5}\text{m})} = .067 \text{ m}$

$(\frac{3}{2} - \frac{1}{2})$ ← Δm; dist b/t fringes ← Δx

c) $f = 5.45 \times 10^{14}$ Hz (frequency doesn't change)

d) $v = f\lambda$ The speed decreases in the fluid so the wavelength decreases.

$x = \frac{m\lambda L}{d}$ The distance will decrease because the wave length



5. (10 points)

A wide beam of white light is incident normal to the surface of a uniform oil film. An observer looking down at the film sees green light that has maximum intensity at a wavelength of 5.2×10^{-7} m. The index of refraction of the oil is 1.7.

n λ

(a) Calculate the speed at which the light travels within the film.

(answer given b/c part of next chapter)

$v_{oil} = c/n = (3.00 \times 10^8 \text{ m/s})/1.7$

$v_{oil} = 1.8 \times 10^8$ m/s

(b) Calculate the wavelength of the green light within the film.

$f_{air} = f_{film}$

$\frac{V_{air}}{\lambda_{air}} = \frac{V_{film}}{\lambda_{film}}$

$\lambda_{film} = \frac{\lambda_{air} V_{film}}{V_{air}} = \frac{(5.2 \times 10^{-7} m)(1.8 \times 10^8 m/s)}{(3.00 \times 10^8 m/s)} = 3.12 \times 10^{-7} m$

OR $\lambda_f = \frac{\lambda_{air}}{n} = \frac{5.2 \times 10^{-7} m}{1.7} = 3.06 \times 10^{-7} m$

(c) Calculate the minimum possible thickness of the film.

phase change + path difference = constructive

$\frac{1}{2}\lambda + 2t = \lambda_{oil}$

$2t = \frac{\lambda_{oil}}{2}$

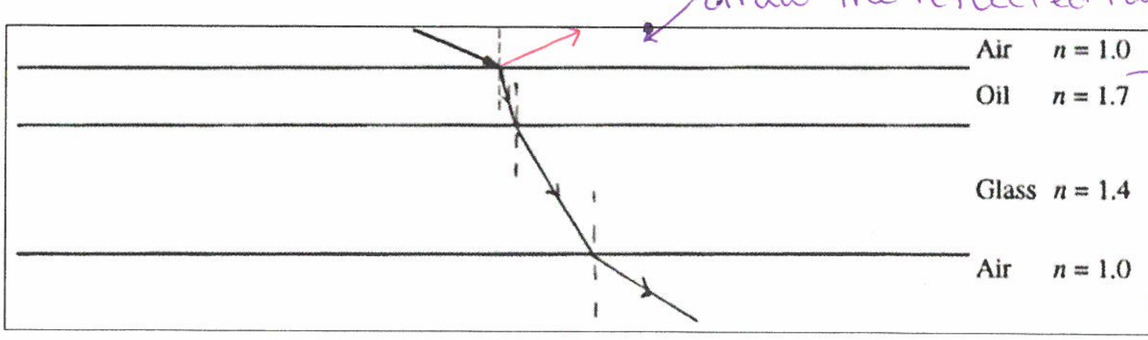
$\lambda_{oil} = 4t$ $t = \frac{\lambda_{oil}}{4} = \frac{3.12 \times 10^{-7} m}{4} = 7.8 \times 10^{-8} m$

or $t = \frac{\lambda_{air}}{4n} = \frac{5.2 \times 10^{-7} m}{4(1.7)} = 7.6 \times 10^{-8} m$

or $t = \frac{\lambda_f}{4} = \frac{3.06 \times 10^{-7}}{4} = 7.65 \times 10^{-8} m$

(d) The oil film now rests on a thick slab of glass with index of refraction 1.4, as shown in the figure below. A light ray is incident on the film at the angle shown. On the figure, sketch the path of the refracted light ray that passes through the film and the glass slab and exits into the air. Clearly show any bending of the ray at each interface. You are NOT expected to calculate the sizes of any angles.

draw the reflected ray



(refracted rays given b/c part of next chapter)