General Physics II Recitation Quiz 10 - Interference, Diffraction, Polarization Mar. 31, 2010

Name:

For full credit, make your work clear. Show the formulas you use, all the essential steps, and results with correct units and correct number of significant figures.

1(3). Blue light (wavelength 400 nm) falls on a narrow slit that produces a diffraction pattern on a screen 5.0 m away. The width of the central maximum is 4 mm. How does this width change if a blue light is replaced with a red light (wavelength 700 nm).

$\sin\theta_{BLUE} = \lambda_{BLUE}/D \approx x_{BLUE}/L$, where $L = 5.0$ m and $x_{BLUE} = 4.0$ mm;

For the red light we have

$$\sin\theta_{RED} = \lambda_{RED}/D \approx x_{RED}/L$$

Hence $L/D \approx x_{BLUE}/\lambda_{BLUE} = x_{RED}/\lambda_{RED}$

and $x_{RED} = 7.0$ mm

2 (3). White unpolarized light passing through a Polaroid sheet is replaced with a plane-polarized light of the same intensity. It is known that the intensity of the light behind the Polaroid also remained the same. Determine the angle between the transmission axis of Polaroid and the original orientation of the plane-polarized light.

For unpolarized light $I = \frac{1}{2} \times I_0$ For polarized light $I = I_0 \times \cos^2\theta$

$\frac{1}{2} = \cos^2\theta$, hence $\theta = 45°$

3.(4) If a soap bubble is 120 nm thick, what wavelength is most strongly reflected at the center of the outer surface when illuminated by white light? The index of refraction in the soap bubble is 1.34

Let $t = 120$ nm and $n = 1.34$

The path difference between the wave reflected from the outer surface and the wave reflected from the inner surface is $2t$.

The wave reflected from the outer surface will have the additional phase difference $= \pi$; while the wave reflected from the inner surface will not.

Therefore the constructive interference between two waves is observed, when the path difference is $(m + \frac{1}{2})\lambda_{soap}$.

Note it is $(m + \frac{1}{2})$ - number of wavelengths rather than an integer number of wavelengths, because the light reflected from the outer surface changes the phase (equivalent to a travel distance of $\frac{1}{2}\lambda$), while the light reflected from the inner surface does not change the phase.

$2t = (m + \frac{1}{2})\lambda_{soap}$

For $m = 0$ we get $2t = \frac{\lambda_{soap}}{2} = \frac{\lambda}{2n}$

$\lambda = 4tn = 643$ nm.

Alternative Solution:

With respect to the incident wave, the wave that reflects from the outer surface has a phase change of $\phi_1 = \pi$.

With respect to the incident wave, the wave that reflects from the inner surface has a phase change due to the additional path-length only: $\phi_2 = (\frac{2t}{\lambda_{soap}}) \cdot 2\pi$.

For constructive interference the net phase change should be $\Delta\phi = 2m\pi$,

which gives us $2m\pi = (\frac{2tn}{\lambda}) \cdot 2\pi - \pi$

and for $m = 0$, $\lambda = 4tn = 643$ nm.