Physics 173-1,2
Spring Quarter 1985
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George Williams

3RD MIDTERM

$n = 200$
$\bar{x} = 18.0$
$\sigma = 5.53$

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Grader
~~Name (Print)~~ Pollard

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Discussion Instructor (CIRCLE ONE): Crelly Kao Luty McDonald

Discussion Section #: _____ Pollard Saffer

SHOW ALL WORK!! Report all numbers to three significant figures!
Use the conversion constants and data given on the front page.

(a) For a single slit illuminated by red light (λ = 650 nm) the third minimum on a screen 10.0 m away from the slit is 3.75 cm from the center. Find the wavelength for which the fifth minimum is the same distance from the center. 390 nm

(b) A two-slit pattern shows the 7th, 14th, 21st, etc., maxima are missing. If the slit spacing is 0.0250 cm, what is the slit width? 3.57×10^{-3} cm

(c) It is found that the total rotation of the plane of polarization by 10.0 cm of a sugar solution is 127°. What is the difference between n_r and n_l? $\lambda = 500$ nm

3.53×10^{-6}

(d) Three polarizers are arranged with the transmission axes of each rotated 30° from the one before. What is the maximum intensity of light (as a fraction of the incident intensity I_0) that can pass this system? $I = 0.563 I_0$

(e) Calculate the polarizing angle for a diamond (n = 2.42) submerged in water (n = 1.33). The incident light is from the water side of the boundary.

61.2°

a) $3\lambda_1 = a \sin\theta \approx a \tan\theta = a \frac{y}{D}$

$a = \frac{3\lambda_1 D}{y}$ ← $y/D << 1$

$5\lambda_2 \approx a \tan\theta = \frac{3\lambda_1 D}{y} \quad \frac{y}{D} = 3\lambda_1$

$\lambda_2 = \frac{3}{5}\lambda_1 = \frac{3}{5}\, 650\,nm = 390\,nm$

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b) $m\lambda = a \sin\theta$ single slit minima

$M\lambda = d \sin\theta$ double slit maxima

For this problem

$m = 1, 2, 3, \ldots$

Corresponds spatially to → $M = 7, 14, 21, \ldots$

So

$\frac{m\lambda}{M\lambda} = \frac{a \sin\theta}{d \sin\theta}$

$a = d \frac{m}{M} = \frac{0.0250}{7}\,cm$

$a = 3.57 \times 10^{-3}\,cm$

c) $\phi = \frac{\pi d}{\lambda} \Delta n$ $\quad$ n is a number $\Rightarrow$ no units

$$\Delta n = \frac{\phi \lambda}{\pi d} = \frac{127\left(\frac{\pi}{180}\right)(500\times10^{-9})}{\pi\,(.100)} = 3.53\times10^{-6}$$

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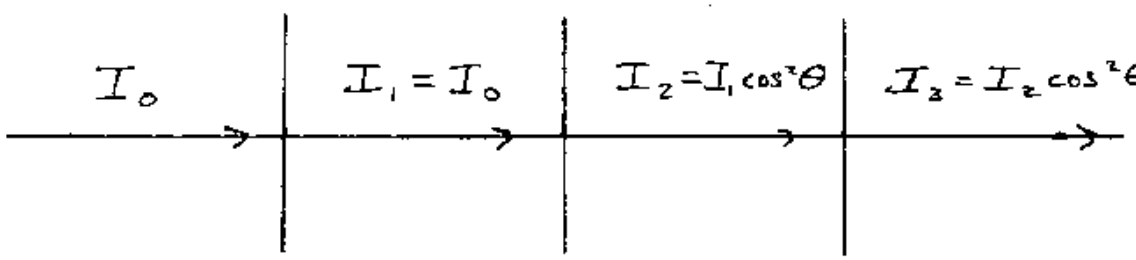
d) I_o is plane polarized. To maximize the intensity, align the first polarizers' transmission axis with the incident polarized light, then



$$I_3 = I_2 \cos^2\theta = I_1 \cos^4\theta = I_o \cos^4\theta \quad ; \theta = 30°$$

$$\Rightarrow I_{\substack{max \\ out}} = 0.563\, I_o$$

Many people missed this one.

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e) Polarizing angle $\Rightarrow \tan\theta_p = \frac{n_{diamond}}{n_{water}} = \frac{2.42}{1.33}$

$$\theta_p = \tan^{-1}\left(\frac{2.42}{1.33}\right) = 61.2°$$

-1 wrong significant figures/occurrence

-1 wrong units/occurrence

Page 1 commentary

It is "customary" to give solutions in the same units as the problem is stated. There are certain exceptions, these are dictated by "taste."

Below is a list of reported correct answers.

a) 390 nm, 3.90×10^{-7} m, 3.90×10^{-5} cm, 3.90×10^{-4} mm, 3900 Å

b) 3.57×10^{-3} cm, 3.57×10^{-5} m, 35.7 μm, 3.57×10^{-2} mm

c) 3.53×10^{-6} (no units)

d) $0.563\,I_o$, $\frac{9}{16}I_o$, 0.563, 9/16

If you had the pleasure of taking the test in naval science bldg., you were not told the incident light was plane polarized. Assuming totally non-polarized incident light

$$I = \tfrac{1}{2}(0.563)I_o = 0.282\,I_o = \tfrac{9}{32}I_o$$

e) 61.2°, 1.07 rad. either one o.k.