Physics 2220
Spring Semester 2008
George A Williams

EXAM 5

1

Name: _____ unid: u _ _ _ _ _ _ _ _

Discussion TA (circle): Justin Mahamadou (Mike) Will

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

(a) Calculate the critical angle for total internal reflection for glass (n = 1.55) immersed in water (n = 1.33).

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 \sin\theta_c = n_2 \sin 90°$

$\sin\theta_c = \frac{n_2}{n_1} = \frac{1.33}{1.55}$

$\theta_c = \sin^{-1}\left(\frac{1.33}{1.55}\right) = 59.1°$

(b) A concave spherical mirror has a radius of curvature of 1.20 m. Calculate the position of the image of an object 1.45 m away from the mirror.

Concave mirror has positive focal length $f = R/2$

$f = 1.20/2 = 0.6$ m

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \Rightarrow \frac{1}{1.45} + \frac{1}{q} = \frac{1}{0.6}$

$q = 1.02$ m

(c) A soap film (n = 1.33) is observed to show a reflection maximum in perpendicular incidence at a green wavelength of 525 nm. What is the minimum thickness of the soap film you can deduced from this data?

The light has a 180° phase change at the top of the film, but not when reflecting off the bottom. For constructive interference,

$2t = (m + 1/2)\frac{\lambda}{n}$

Smallest t when $m = 0$

$t = \frac{\lambda}{4n} = \frac{525\text{ nm}}{4(1.33)} = 98.7$ nm

(d) Sunlight is incident on the physics parking lot with an intensity of 750 W/m^2. Calculate the maximum value of the magnetic field in this light beam.

$I = S_{avg} = \frac{c B_{max}^2}{2\mu_0} \Rightarrow B_{max} = \sqrt{\frac{2\mu_0 I}{c}}$

$B_{max} = \sqrt{\frac{2(4\pi\times10^{-7})(750)}{3\times10^8}} = 2.51\times10^{-6}$ T

(e) A green laser has a wavelength of 525 nm. Calculate its wavelength in diamond (n = 2.40).

$\lambda_n = \frac{\lambda_{vacuum}}{n} = \frac{525\text{ nm}}{2.40} = 219$ nm

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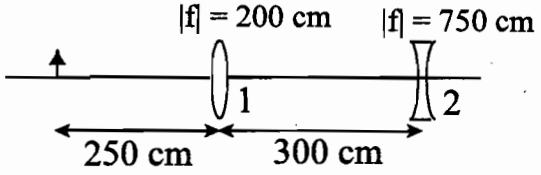
SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

For the lens system shown, there is a real object 250 cm to the left of lens 1. You supply the sign for the focal lengths of the lenses.



(a) Calculate the position, measured from the center of lens 2, of the final image (+ right, - left).
(b) Is the image erect or inverted?
(c) Is the image real or virtual?
(d) Calculate the magnification of the system.

a.) $\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{f_1}$ $f_1 = 200\,cm$ $p_1 = 250\,cm$

$\frac{1}{q_1} = \frac{1}{200cm} - \frac{1}{250cm}$

+7 $q_1 = 1000\,cm$

$p_2 = 300cm - 1000cm = -700cm$

+6 $\frac{1}{p_2} + \frac{1}{q_2} = \frac{-1}{750cm} \rightarrow \frac{1}{q_2} = \frac{-1}{750cm} + \frac{1}{700cm}$

$q_2 = 10500\,cm$ to the right

+4b.) $M_T = M_1 M_2 = \frac{q_1}{p_1}\frac{q_2}{p_2} = -60$

so inverted

+4 c.) $q_2 > 0$, real

+4 d.) -60

all or nothing unless sign is wrong on M

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3

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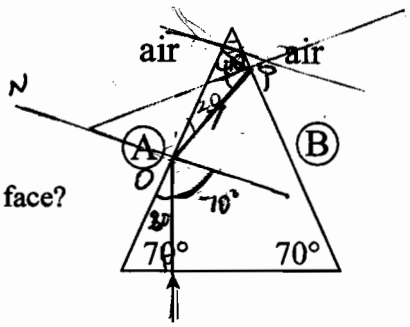
SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

A prism (shown in the drawing) is created of diamond (n = 2.40). Light is incident perpendicular to the bottom of the prism.



(a) How many total internal reflections occur before the beam exits the prism?
(b) Which face, A or B, does it exit?
(c) What is the angle of the emergent beam in air with respect to the normal of that face?

Solution :

a) The critical angle $\theta_c = \sin^{-1}\left(\frac{1}{2.40}\right) = 24.62^\circ$

$\theta_1 = 70 > 24.62 \rightarrow$ total internal reflection at point b

$180 = 20 + 40 + 90 + \theta_2 \Rightarrow \theta_2 = 30^\circ$

$\theta_2 > 24.62 \rightarrow$ total internal reflection at point P.

$180 = 40 + 60 + [illegible] + \theta_3 \Rightarrow \theta_3 = 90 - 80 = 10 < \theta_c$

$\Rightarrow$ Hence we Have 2 total internal reflection at points O and P. (2)

b) light exits at face A.

c) The emergent angle is :

$n \sin 10 = \sin\theta \Rightarrow$ [illegible]

$\theta = \sin^{-1}(2.4 \sin 10) = 24.6$

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Name: Solution unid: u _ _ _ _ _ _ _ _

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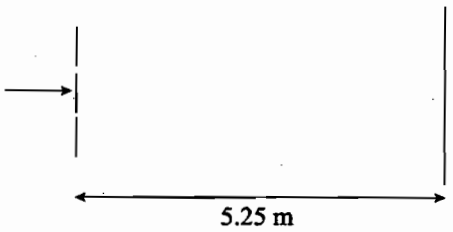
SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

Light of 2 colors, $\lambda = 500$ nm and $\lambda = 600$ nm, is perpendicularly incident on a 2-slit system. The slit separation is 0.250 mm. The distance to the observing screen is 5.25 m.



13 (a) Calculate the separation, in cm, between the m = 0 and m = 1 bright fringes on the screen for the $\lambda = 500$ nm light.

12 (b) Calculate the first two angles where the maximum of the two colors exactly overlap.

a) $\int = d\sin\theta = m\lambda$ for constructive int.

$\therefore \tan\theta = \frac{y}{L} \approx \sin\theta$ at small angles so

$d\frac{y}{L} = m\lambda \rightarrow y = \frac{m\lambda L}{d}$ (distance to maximum)

$y_1 = \frac{1(500\times10^{-9})(5.25)}{(.250\times10^{-3})} = .0105\text{ m} = \boxed{1.05\text{ cm}}$

$10^{-9+3} = 10^{-6}$

b) Find this location along y direction First.

Using: $\left[y = \frac{m\lambda L}{d}\right]$ $\quad L\left(\frac{m\lambda}{d}\right) = L\left(\frac{m'\lambda'}{d}\right) \Rightarrow \frac{m'}{m} = \frac{\lambda}{\lambda'}$

$\frac{m'}{m} = \frac{500\text{ nm}}{600\text{ nm}} \rightarrow \frac{m'}{m} \rightarrow \frac{5}{6}$

$y = L\frac{m'\lambda'}{d} = \frac{6(500\times10^{-9})}{0.250\times10^{-3}}(5.25)$

(the 6th fringe of the 500nm light overlaps w/ the 5th from the 600nm light.)

$\theta_1 = \tan^{-1}\left(\frac{6(500\times10^{-9})}{0.250\times10^{-3}}\right) = \boxed{1.688^\circ}$

$\theta_2 = \tan^{-1}\left(\frac{12(500\times10^{-9})}{0.250\times10^{-3}}\right) = \boxed{1.38^\circ}$