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Physics 1C

Fall 2015

Midterm # 2

See me after class
~ Summer

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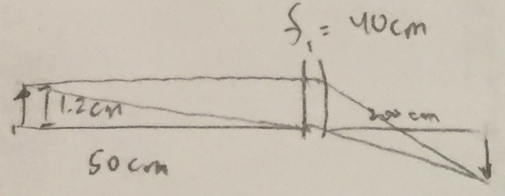
1) A 1.2 cm tall object is 50 cm to the left of a converging lens of focal length $f_1 = 40.0$ cm. A second converging lens, this one having a focal length $f_2 = 60.0$ cm, is located 300 cm to the right of the first lens along the same optical axis.
   a) Find the location and height of the image formed by the lens with focal length 40 cm.
   b) This image plane is now the object for the second lens. Find the location and height of the image produced by the second lens.
   c) What is the total magnification of the system?

a).



$\frac{1}{0.5} + \frac{1}{s'} = \frac{1}{0.4}$

$\frac{1}{s'} = \frac{1}{0.4} - \frac{1}{0.5}$

$s' = 2$ m

$M = -\frac{s'}{s}$

$M = \frac{-2}{0.5}$

$M = -4$

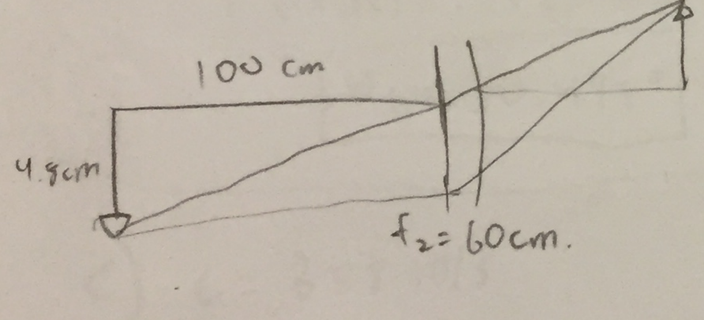
$H = M \cdot H_o$

$H = -4(0.012)$

$= -0.048$ m

The image is 2 m to the right of the lens & -4.8 cm tall. (Upside down)

b)



$\frac{1}{1} + \frac{1}{s'} = \frac{1}{0.6}$

$\frac{1}{s'} = \frac{2}{3}$

$s' = 1.5$ m

$M = \frac{-s'}{s}$

$M = \frac{-1.5}{1}$

$M = -1.5$

$H = -1.5(-0.048)$

$H = 0.072$ m

The image is 1.5 m to the right of the 2nd lens & 0.072 m or 7.2cm tall. (upright)

c) $M = \frac{y'}{y} = \frac{7.2\text{cm}}{1.2\text{cm}} = \frac{0.072\text{ m}}{0.012\text{ m}}$

$= 6$

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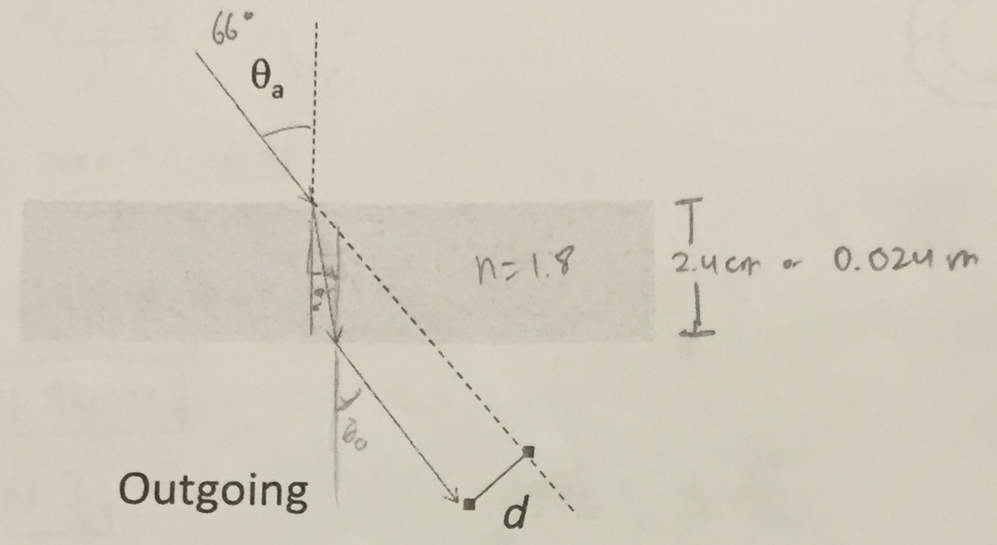
2) Light is incident in air ($n=1$) at an angle θ_a on the upper surface of a transparent plate, the surfaces of the plate being plane and parallel to each other. Assume an incident angle of 66 degrees and a 2.40 cm thick slab of glass (n = 1.8).

a) What is the angle of the light inside the plate ?
b) What is the angle of the outgoing radiation with respect to the normal?
c) Calculate the lateral displacement *d* of the emergent beam ?
d) For which incident angle the reflected light will be completely polarized?



a). $n_a \sin\theta_a = n_b \sin\theta_b$

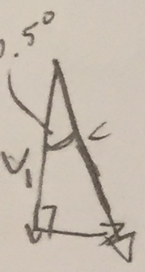
$1 \sin(66) = 1.8 \sin(\theta_b)$

$\theta_b = 30.499°$ ✓

b) $n_b \sin\theta_b = n_a \sin\theta_a$

$1.8 \sin(30.499) = 1 \sin(\theta_a)$

$\theta_a = 66°$ ✓ makes sense...



c) $c = 3E8$ m/s

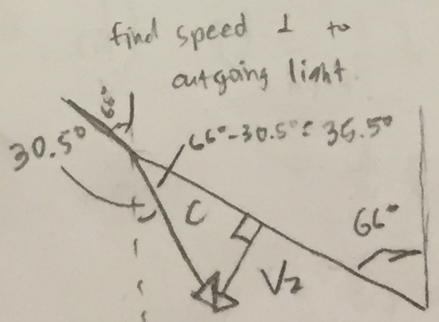
$\cos(30.499°) = \frac{V_1}{c}$

$V_1 = 258491064.6$ m/s downward.

$t = \frac{d}{v}$

$t = \frac{0.024}{258491064.6}$

$t = 9.28465363E-11$ secs.



$\sin(35.5°) = \frac{V_2}{c}$

$V_2 = 174214602.4$ m/s

$d = V_2 \cdot t$

$= (174214602.4)(9.28465363E-11)$ m/s sec

$= 0.016175$ m or 1.62 cm ✓

d) $\tan\theta_p = \frac{n_b}{n_a}$

air to plate

$\tan\theta_p = 1.8$

$\theta_p = 60.94°$ ✓

plate to air

$\tan\theta_p = \frac{1}{1.8}$

$\theta_p = 29.054$

$I = 100A$ $R = 3.1\,cm$ or $0.031\,m$

3) The magnetic field inside a solenoid is 4.5 T. The solenoid has an inner diameter of 6.2 cm and a length of 26 cm. Determine: $\ell = 0.026m$

a) the number of turns in the solenoid
b) the inductance of the coil
c) the magnetic energy density in the field
d) the energy stored in the magnetic field within the solenoid

a. $B = \frac{\mu_0 I N}{\ell}$

$4.5 = \frac{(4\pi E{-}7)(100A)N}{0.26m}$

$N = 9310.564$

approx. 9311 turns

b) $L = \frac{N \Phi_B}{I}$

$\Phi_B = BA$

$= (4.5)(\pi (0.031)^2)$

$= 0.013586817\,4$

$L = \frac{(9310.56)(0.013586)}{100\,A}$

$L = 1.264916\,25\,H$

$L = 1.265\,H$

c) $u = \frac{1}{2}\frac{B^2}{\mu_0}$

$= \frac{1}{2}\frac{(4.5)^2}{\mu_0}$

$= 8057218.997\,\frac{J}{m^3}$

$= 8.06E6\,\frac{J}{m^3}$

d) $U = \frac{1}{2}LI^2$

$= \frac{1}{2}(1.265\,H)(100A)^2$

$= 6324.158125\,J$

$= 6324.6\,J$ ✓

$Vol = \ell \pi R^2$

$= (0.26)(\pi)(0.031^2)$

$= 7.849E{-}4\ m^3$

$u = 8.06E6\,\frac{J}{m^3}$

$U = (8.06E6\,\frac{J}{m^3})(7.849E{-}4\,m^3)$

$= 6324.581255$ ✓