Physics 116b Test 3b   November 08, 2007

Name:_____Key_____ Seat Row/Number:___/___

This is a 50 minute, closed book examination. Put answers in the boxes provided (if any). If numerical answers are needed, you must include units. Any work needed to justify the answer must be shown in the space provided, or as indicated on a separate piece of paper or elsewhere on the test. A correct answer without the necessary justifying work may not receive any credit. You may tear the formula sheet off the back of the exam.

Total points for each problem will appear in the table below and in ( ) beside each problem number. Do what is easiest first. AVOID glancing at anyone else's paper during the exam. No means of communication between other students or outside parties is allowed. **The honor code is in effect.**

You must do all the problems on this test.

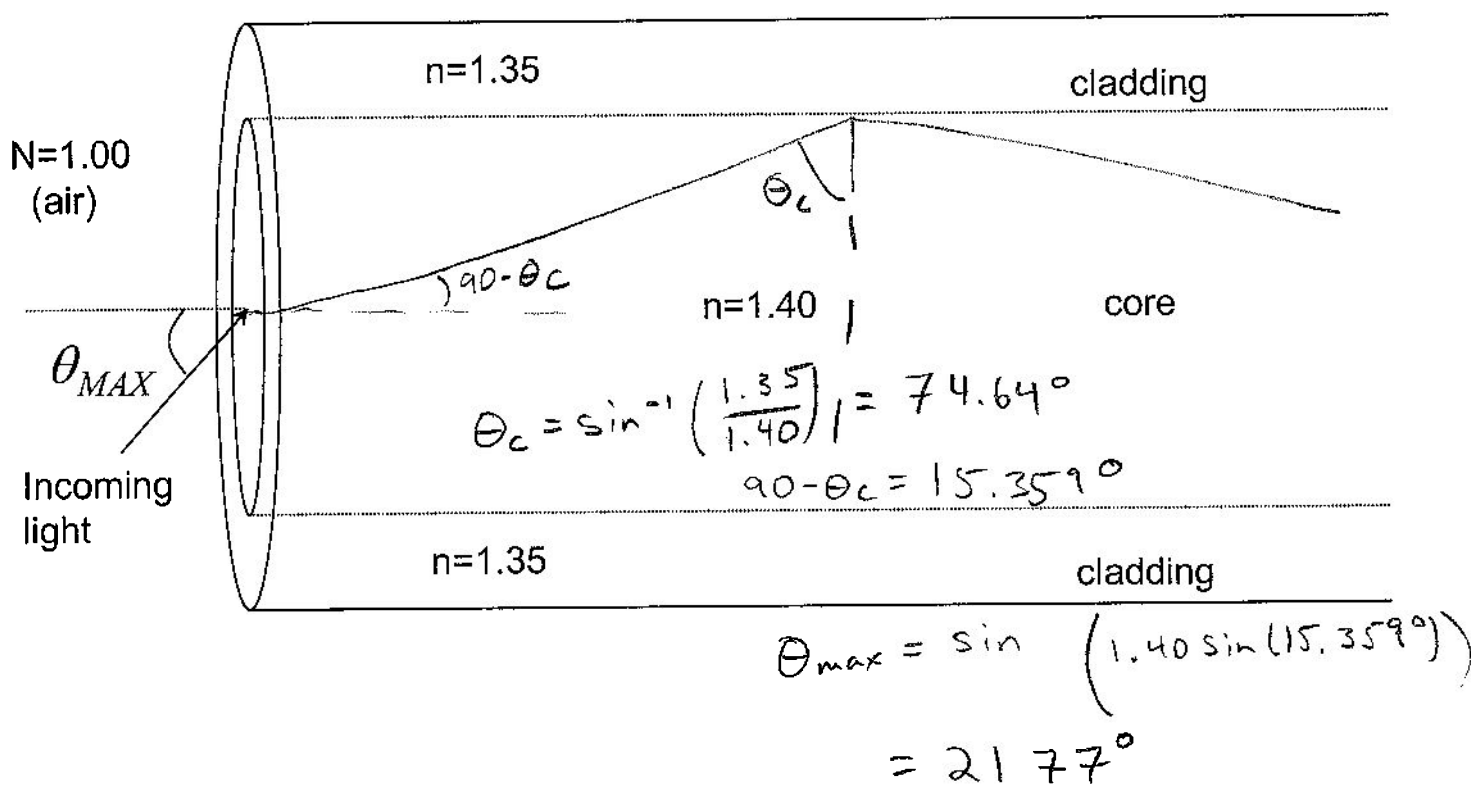| Problem	Description	Max Score	Score
1	Short Answer	16	
2	EM waves, Polarization	13	
3	Lenses, Mirrors	14	
Total		43	

1) Short Answer (Show Your Work!)

a) In which direction is the magnetic field pointing? (2 pts)

B out of page

S   E
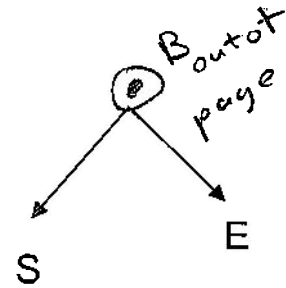
b) A particular fiber optic cable consists of a core inner fiber with index of refraction n=1.40 and an outer shell (called a cladding) that has an index of refraction of n=1.35. What is the maximum angle that light can be shown into the end of the fiber so that the refracted light is totally contained in the core of the fiber? (4 pts)

$$\theta_{MAX} = 21.77^{\circ}$$

n=1.35   cladding

N=1.00
(air)

θ_c

$90-\theta_c$

n=1.40   core

θ_{MAX}

$$\theta_c = \sin^{-1}\left(\frac{1.35}{1.40}\right) = 74.64^{\circ}$$

Incoming
light

$$90-\theta_c = 15.359^{\circ}$$

n=1.35   cladding

$$\theta_{max} = \sin\left(1.40 \sin(15.359^{\circ})\right)$$

$$= 21.77^{\circ}$$

1) Short Answer cont'd (Show Your Work!)

c) The power company is complaining that your company has too big of an inductive load. The phase angle between the max current and the max voltage is 30 degrees. Assuming your company consumes an average 20,000 Watts of 120V (rms) (169.7V max) power, and has no capacitance in its load, what is your company's inductive load (inductance)? (4 pts) What size capacitor do you need to add to make the phase angle 0 degrees? (2 pts) (hints: The power has f = 60Hz & V=IZ & use phase angle)

$\phi = 30°$

$P_{avg} = \frac{1}{2} V_{max} I_{max} \cos\phi$

$= \frac{1}{2} V_{max} \frac{V_{max}}{Z} \cos\phi$

$Z = \frac{1}{2} \frac{V_{max}^2}{P_{avg}} \cos\phi$

$$\boxed{L = 8.27 \times 10^{-4}\ H \\ C = 8.5 \times 10^{-3}\ F}$$

$\cos\phi = \frac{R}{Z}$ so, $\sin\phi = \frac{\omega L}{Z}$

$\tan\phi = \frac{\omega L - 0}{R}$

$L = \frac{1}{\omega} Z \sin\phi = \frac{1}{2\omega} \frac{V_{max}^2}{P_{avg}} \cos\phi \sin\phi$

$= \frac{1}{(4\pi \frac{60}{s})} \frac{(169.7V)^2}{20,000 W} \cos 30° \sin 30° = 8.27 \times 10^{-4} H$

units?

$\frac{V^2}{\frac{1}{s} V^2} = \Omega s$

$\frac{V^2}{\frac{1}{s} \Omega} = \Omega s$
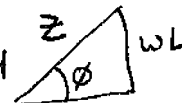
find C, @ res $\phi = 0$ $\omega L = \frac{1}{\omega C}$ $C = \frac{1}{\omega^2 L} = \frac{1}{(2\pi \frac{60}{s})^2 8.27 \times 10^{-4}}$

Ωs

$= 8.5 \times 10^{-3} F$
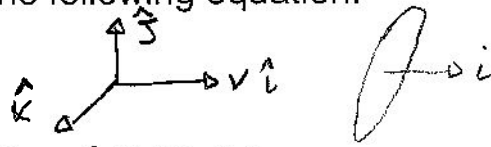
$\frac{s}{\Omega}$

d) Find the image for the object and lens shown below using graphical methods (ray tracing) (4 pts.)

|f| |f|
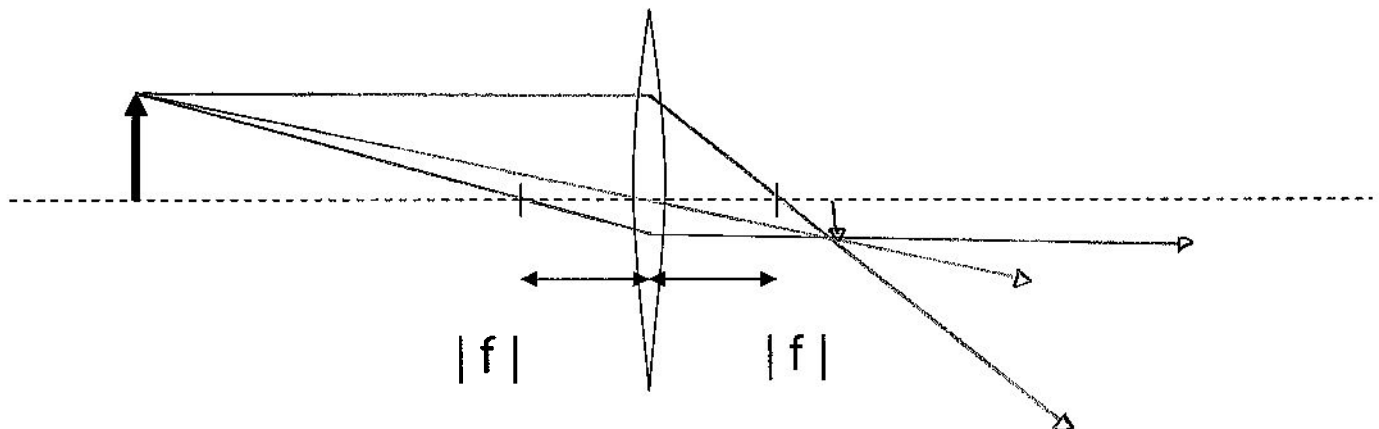
2) EM waves and Polarization (show your work, make a brief explanation)

An electro-magnetic wave is described by the following equation:

$$\vec{E}(x,t) = E_0 \sin(\frac{1.25e7}{m}x - \frac{3.75e15}{s}t)\hat{j}$$

In what direction is this wave traveling ($\hat{i}$, $\hat{j}$, or $\hat{k}$)? (2 pts)

direction = $\hat{i}$

In order to absorb this wave completely with a polarizer, in which direction should the Transmission axis of the polarizer be oriented ($\hat{i}$, $\hat{j}$, or $\hat{k}$)? (2 pts)

E along $\hat{j}$

want $\perp$

direction = $\hat{k}$

In which *plane* should the plane of this polarizer be placed(ij, jk, or ik)? (2 pts)

plane = jk

With this polarizer set in place, a new polarizer is placed in front of it (so the electro-magnetic wave hits the new polarizer first). At what angle, relative to the initial polarization (direction of E_0) of the electromagnetic wave, should the Transmission Axis of this new polarizer be placed in order for 1/6th of the original intensity to pass completely through *both* polarizers ($I_{FINAL}=I_0/6$)? (hint: you may find the identity: $0.5\sin(2\theta) = \cos(\theta)\sin(\theta)$ useful (4 pts)

$\hat{j}$ E_0

θ

$0-\theta$

$\hat{k}$

$I_{final} = I_0 \cos^2\theta \cos^2(90-\theta)$

$= I_0 \cos^2\theta \sin^2\theta$

$= I_0(.25) \sin^2 2\theta$

$\frac{1}{6} = 0.25 \sin^2 2\theta$ $\theta = (\sin^{-1}\sqrt{\frac{2}{3}})/2 = 27.4°$

Angle = $27.4°$

If E_0 is 5,000V/m, what is the value of the original (average) Intensity? (3 pts)
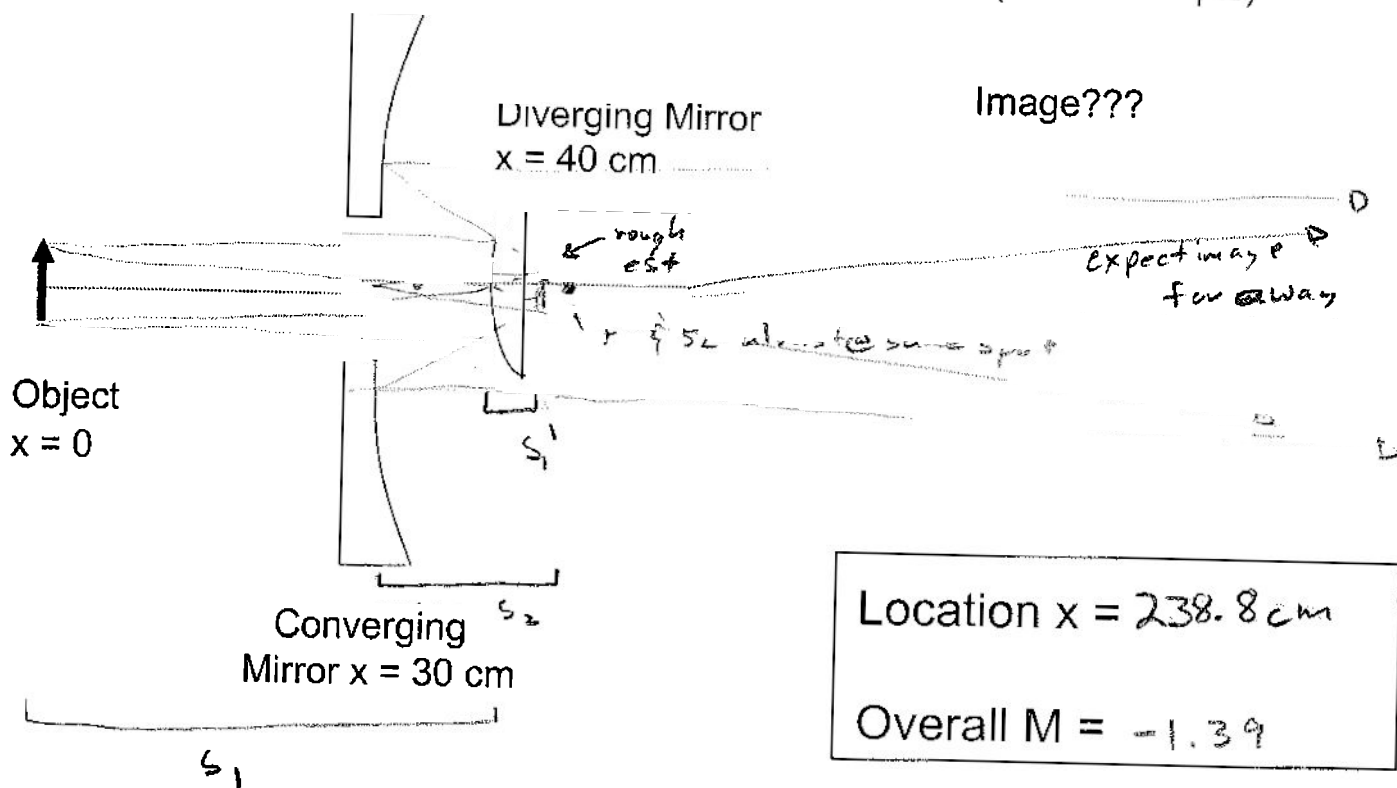
$S_{avg} = \frac{E_{max} B_{max}}{2\mu_0}$ $B = E/c$

$I_0 = \frac{E_0^2}{2c\mu_0} = \frac{(5000^{N/c})^2}{2(3\times10^8\frac{m}{s})(4\pi\times10^{-7}(\frac{N}{mA})\frac{m}{A})}$

$= 33157 \frac{W}{m^2}$

Intensity = $33 \frac{kW}{m^2}$

units? $\frac{N^2}{c^2}$ ÷ $\frac{m}{s}\frac{N}{c^2/s^2}$ = $\frac{N}{ms} = \frac{Nm}{m^2 s}$

$W = \frac{Nm}{s}$

3) Weird Slide Projector (Show your work!)

We are examining another overhead projector design. The light from the object at x=0 passes through a hole (the hole won't hurt the final image much) in the converging mirror at x=30 cm and strikes the diverging mirror at x=40cm.
If the converging mirror has a radius of curvature of 25.6 cm and the diverging mirror has a radius of curvature of 8.0 cm Where (x = ?) does the final image of this system form? (8 pts) What is the overall magnification (4 pts) Will this work as well as the overhead projector we usually use? (Reasons 2 pts)

Diverging Mirror
x = 40 cm

Image???

rough est

expect image for away

r & s_2 almost the same spot

Object
x = 0

S_1'

Converging
Mirror x = 30 cm

S_2

S_1

Location x = 238.8 cm

Overall M = −1.39

$$S_1' = 1 \bigg/ \left(\frac{1}{-4.0cm} - \frac{1}{40.0cm} \right) = -3.636 \, cm$$

$$f = -\frac{R}{2} \text{ div mir}$$

$$M_1 = -\frac{S_1'}{S_1} = \frac{-(-3.636)}{40} = 0.0909$$

$$S_2 = 10cm + 3.636cm = 13.636 cm$$

$$S_2' = 1 \bigg/ \left(\frac{1}{12.8cm} - \frac{1}{13.636} \right) = 208.8cm \Rightarrow 238.8cm \text{ in } x$$

$$f = \frac{R}{2} \text{ conv. mirr}$$

$$M_2 = -\frac{S_2'}{S_2} = -\frac{208.8}{13.636} = -15.25$$

don't
work
well since
out it big
for overhead

easy to fix

$$M_{tot} = = -1.39 \boxed{\text{too small!!}}$$