2

Physics 116b

Third Partial Examination

November ~~X~~ 2000

Name: Key

I.D.#:

Signature:

Please circle your section:

Section 1 2 3 4

Instructions

This is a one hour+, closed book examination. Put answers in the boxes provided, or circle the best answer. If numerical answers are needed, you must include units. Any work needed to justify the answer must be shown in the space provided. A correct answer without the necessary justifying work may not receive any credit. You may use the formula sheet at the back of the exam.

Total point scores 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! The Honor Code is in effect. Please sign the exam to indicate your Honor Pledge. Good luck!

Point Tallies for the Exam Problems

Problem	Max Score	Actual Score
1	15	
2	15	
3	15	
4	15	
Total		

I III
V V
1) Short Questions (Showing work can get you partial credit) II VI

(Circle the Correct Response):

a) How much energy is stored in a solenoid of length 10 *cm*, area 5.0 cm^2 and 100 turns of wire if it carries 12.0 amps? (3 pts)

I) 4.52 milli-Joules
II) 754 micro-Joules
III) 720 micro-Joules
IV) 5.23 micro-Joules
V) 218 nano-Joules

$U = \frac{1}{2} L I^2$

$L = \mu_0 n^2 A l = \mu_0 N^2 \frac{A}{l}$

$= 4\pi \times 10^{-7} \frac{H}{m} (100)^2 \left(\frac{5.0 cm^2}{10 cm}\right)\left(\frac{1m}{100cm}\right)^2\left(\frac{100cm}{1m}\right)$

$= 6.28 \times 10^{-5} H$

$U = \frac{1}{2}(6.28 \times 10^{-5} H)(12.0 A)^2$
$= 4.52 \times 10^{-3} J$

b) In 3.0 *seconds* the current in a particular RL circuit that consists of a battery, a resistor, and an inductor connected in series, has increased to a value that is 50% of the maximum current possible. If the resistor has a value of 3.00 Ohms, what is the inductance of the inductor? (3 pts)

I) 0.69 Henrys
II) 1.4 Henrys
III) 2.0 Henrys
IV) ~~4.3 Henrys~~
V) 13 Henrys

find time constant

$.5 I_0 = I_0(1 - e^{-t/\tau})$

$.5 = e^{-3/\tau}$

$\ln(.5) = -3/\tau; \quad \tau = \frac{-3}{\ln(.5)} = 4.33 s$

$\tau = \frac{L}{R} \quad L = R\tau = (3.00 \Omega)(4.33 s)$
$= 13 \Omega s = 13 H$

c) A laser beam passes from air to glass. What happens to the wavelength of this light?(2 pts)

I) Increases
II) ~~Decreases~~
III) Stays the same

$n_1 \lambda_1 = n_2 \lambda_2$

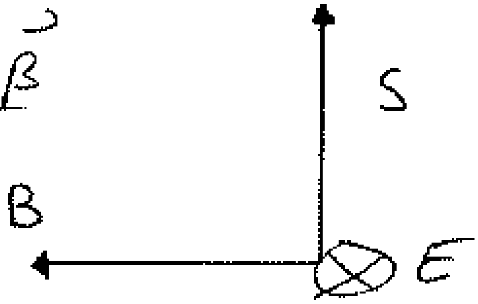
$\lambda_2 = \frac{\lambda_1}{n_2} \quad n_2 > 1$

$\lambda_2 < \lambda_1$

1) Short Questions (continued)

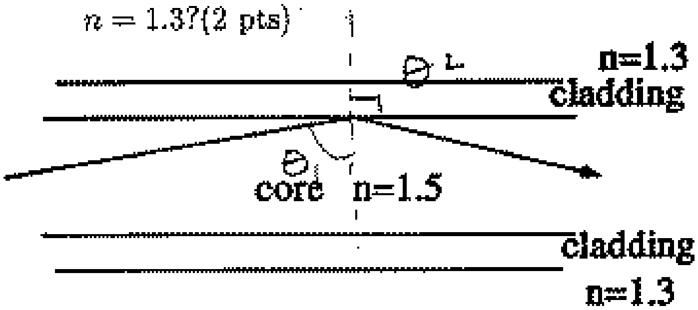
d) In which direction is this Electric Field pointing for this travelling elecromagnetic wave?(2 pts)

$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$$



I) Up
II) Down
~~III) Into the Page~~
~~IV) Out of the Page~~

e) What is the critical angle for total internal reflection for light traveling in the core (inner part) of an optical fiber if the core has an index of refraction of $n = 1.5$ and the cladding (outer covering) of the fiber has an index of refraction of $n = 1.3$?(2 pts)



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

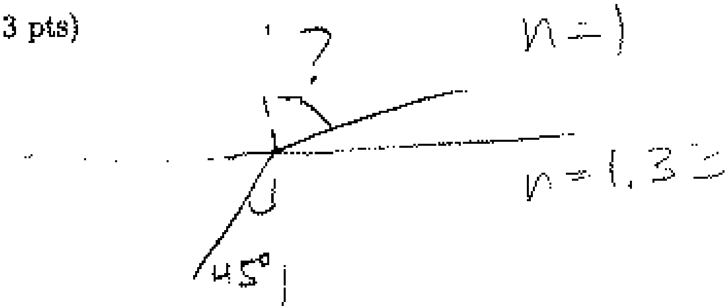
$$1.5 \sin\theta_c = 1.3$$

$$\sin\theta_c = \frac{1.3}{1.5}$$

$$\theta_c = \sin^{-1}\frac{1.3}{1.5} = 60^\circ$$

I) $\theta = 30^0$
II) $\theta = 40^0$
III) $\theta = 42^0$
~~IV) $\theta = 50^0$~~
V) $\theta = 60^0$

f) A flying fish, under water (n=1.33), sees the sun at an apparent angle of 45^0 from the vertical. At what angle from the vertical does this fish see the sun when it "flies" above (n=1.00) the water?(3 pts)



I) $\theta = 20^0$
II) $\theta = 32^0$
III) $\theta = 49^0$
~~IV) $\theta = 60^0$~~
V) $\theta = 70^0$

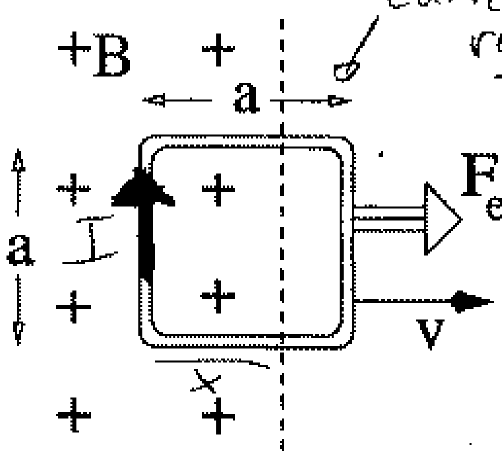
$$1.33 \sin 45^\circ = 1 \sin\theta ?$$

$$\theta = \sin^{-1}\left(\frac{1.33}{\sqrt{2}}\right)$$

$$= 70.1^0$$

2) Induced EMF:15 points (Show your Work!)

In the figure below, an external force is used to move a conducting loop of sides a and a resistance R through a magnetic field at a constant velocity v as shown. This produces an induced Emf in the loop, and a resulting current. If $R = 2.0\ \Omega$, $a = 0.5\ m$, $v = 10\ m/s$, and $B = 0.2\ T$ (B points into the page and is non-zero only to the left of the dotted line as on the figure.):



current resists the Fext or trys to make more B down

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

$$\Phi_B = Bax$$

$$\frac{d\Phi}{dt} = Bav$$

$$V = IR$$

$$I = \frac{V}{R} = \left|\frac{Bav}{R}\right|$$

a) Indicate on the figure the direction of the current.(3 pts.)

b) What is the value of this current?

$$I = \frac{0.2T\ 0.5m\ 10\ m/s}{2.0\ \Omega}$$

$$= 0.5A$$

[$I =$ 0.5 A](6 pts)

c) What is the value of the external force?

$$F = I\ell B$$

$$= (.5A)(.5m)(.2T)$$

$$= 0.05N$$

[$F_{ext} =$ 0.05N](6 pts)

$$F = \frac{I^2 R}{v} = \frac{(0.5A)^2\ 2.0\Omega}{10\ m/s}$$

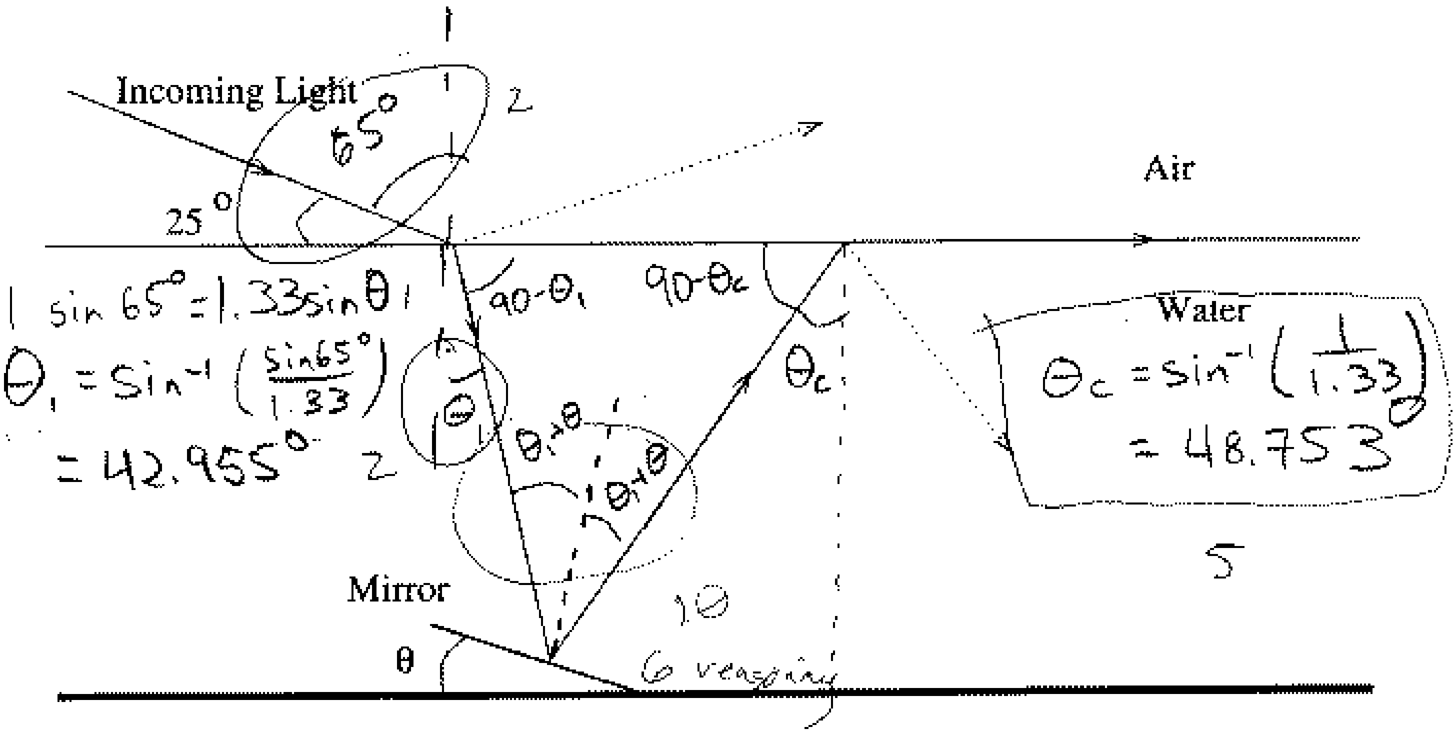
$$= 0.05N$$

check $P = Fv = VI$
$= I^2 R$

3) Refraction (15 points)

A mirror sits at the bottom of a pool. Light is incident on the surface of the pool as shown, strikes the mirror, and is reflected back towards the surface. What is the minimum angle with which you can tilt the mirror so that none of the light reflected by the mirror escapes the pool? The index of refraction for water is 1.33 and that for air is 1.

(note: Figure is a guide only! I.e. you can't "measure" the answer from the figure!)



(Try to show as much work as you can for partial credit.)

$$(\cancel{90}-\theta_1)+(\cancel{90}-\theta_c)+2(\theta_1+\theta) = 180°$$

$$\boxed{\theta = 2.90°}$$

$$\theta_1 - \theta_c + 2\theta = 0$$

$$2\theta = \theta_c - \theta_1$$

$$\theta = \frac{\theta_c - \theta_1}{2} = \frac{48.753° - 42.955°}{2}$$

$$= 2.899°$$

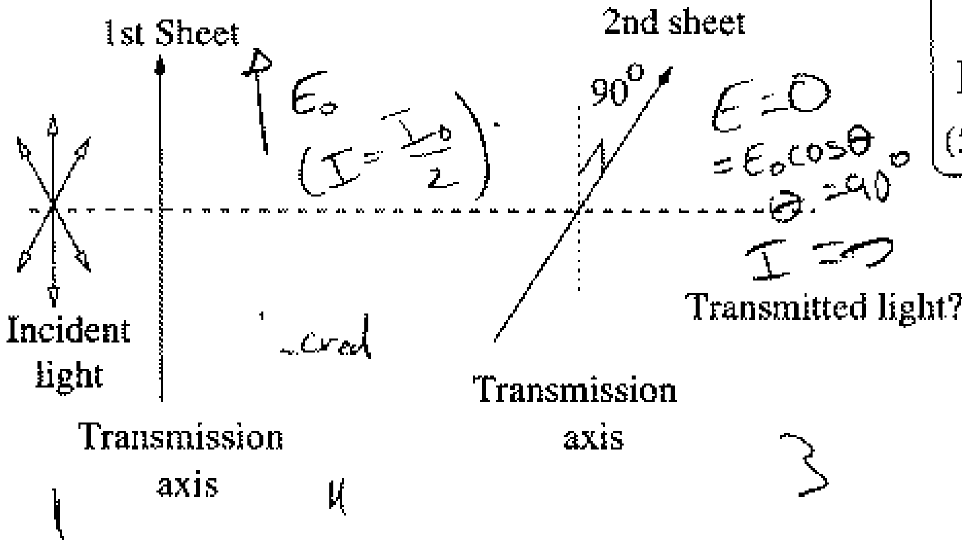
check, if $\theta = 0$ $\theta_c \Rightarrow \theta_1$ (but not critical)

OK!

4) Polarization (15 points) (Show your work!)

Initially unpolarized light is incident upon 2 polarizers. These polarizers have their transmission axes oriented at 90 degrees relative to each other. If the incident light has an intensity of $I=15.0\ W/m^2$ (light is moving to the right)

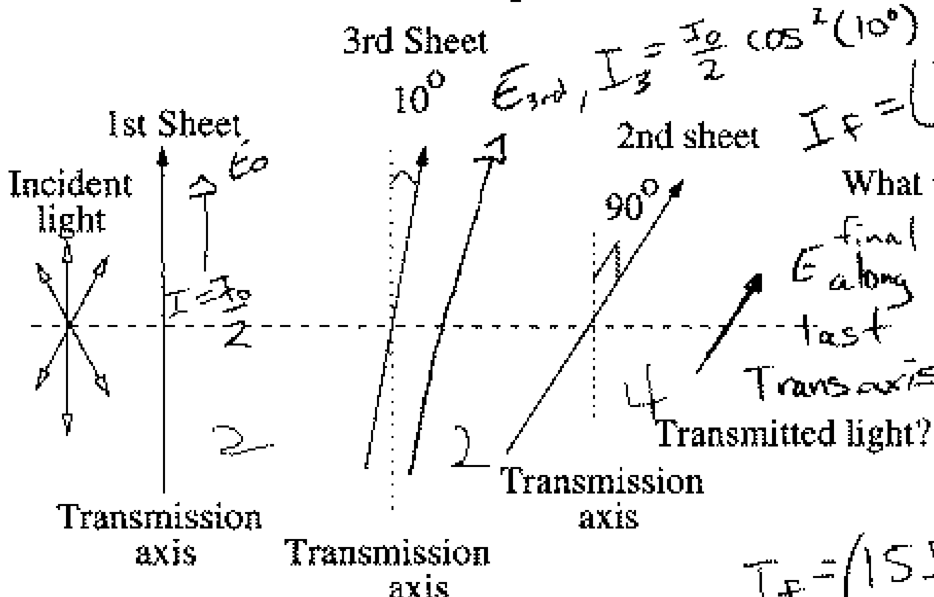
What is the intensity of the transmitted light?



$I = 0$

(5 pts.)

Now, a third sheet is inserted between the 1st and 2nd sheet at an angle of 10 degrees relative to the first sheet.(Indicate on the figure the direction of the transmitted Electric Field, if any (2 pts.))



$I_F = \left(\frac{I_0}{2}\cos^2 10^\circ\right)\left(\cos^2(80^\circ)\right)$

diff bet. polarizers

What is the intensity of the transmitted light?

$I = 0.219\ \frac{W}{m^2}$

(8 pts.)

$$I_F = \frac{\left(15\frac{W}{m^2}\right)}{2}\cos^2 10^\circ \cos^2 80^\circ$$

$$= 0.219\ \frac{W}{m^2}$$

Equations

$$I = \frac{dq}{dt}, \quad I = \int \vec{J} \cdot d\vec{A}, \quad V = IR, \quad P = IV, \quad \vec{F} = m\vec{a}$$

$$\phi_B = \int \vec{B} \cdot d\vec{A}, \quad \varepsilon = -\frac{d\phi_B}{dt}, \quad \phi_B = BA \ (sometimes), \quad \varepsilon = -L\frac{dI}{dt}$$

$$(Increasing) \quad I = I_0(1 - e^{-t/\tau}), \quad \tau = L/R, \quad (decreasing) \quad I = I_0 e^{-t/\tau}$$

$$\vec{F} = I\vec{l} \times \vec{B}, \quad d\vec{F} = I\vec{dl} \times \vec{B}, \quad \phi_E = \int \vec{E} \cdot d\vec{A}$$

$$\oint \vec{E} \cdot \vec{ds} = -\frac{d\phi_B}{dt}, \quad \oint \vec{B} \cdot \vec{ds} = \mu_0\epsilon_0\frac{d\phi_E}{dt} + \mu_0 I_{enclosed}, \quad I_{Displacement} = \epsilon_0\frac{d\phi_E}{dt}$$

$$B = \mu_0 nI \quad (solenoid), \quad L = \mu_0 n^2 Al \quad (solenoid)$$

$$U_L = (1/2)\ LI^2, \quad U_C = (1/2)\ CV^2, \quad u_B = B^2/(2\mu_0), \quad u_E = \epsilon_0 E^2/2$$

$$c = E/B, \quad Pressure = S/c, \quad \vec{S} = (1/\mu_0)\ \vec{E} \times \vec{B}, \quad S_{av} = E_{max}B_{max}/(2\mu_0)$$

$$\vec{E} = \vec{E_0}\sin(kx - \omega t), \quad k = 2\pi/\lambda, \quad \omega = 2\pi f, \quad c_{vacuum} = \lambda f = 1/\sqrt{\epsilon_0\mu_0}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \ \ (Snell's \ \ Law), \quad \sin\theta_c = n_2/n_1, \quad n = c/v, \quad n_1\lambda_1 = n_2\lambda_2$$

$$E = E_0\cos\theta_{polarizer}, \quad I = I_0\cos^2\theta_{polarizer}, \quad \theta_{polarizer} = \theta_E - \theta_{axis}^{transmission}$$

$$I_{unpolarized} \to I_{unpolarized}/2, \quad Work = \int \vec{F} \cdot d\vec{l} = Fl, \quad Power = \frac{dW}{dt} = Fv$$

Constants

$\mu_0 = 4\pi \times 10^{-7}\ \frac{Tm}{A}$

$\epsilon_0 = 8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}$

$c = 3.0 \times 10^8\ m/s$

$g = 9.8\ m/s^2$