Physics 116b

Third Partial Examination   October 28,1999

Name: Key

I.D.#:

Please circle your section:

Section   5   6   7   8

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 tear the formula sheet off 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!

Point Tallies for the Exam Problems

Problem	Max Score	Actual Score
1	14	
2	15	
3	10	
4	10	
Total		

1) Short Questions (2 pt. each)(No need to show your work)

(Circle the Correct Response, or Make a Sketch):

a) What is the self inductance of a solenoid of length 10 cm, area 5.0 cm^2 and 100 turns of wire?

I) 10 micro-Henrys
II) 63 micro-Henrys
III) 310 Henrys
IV) 4.0 mega-Henrys
V) 10 Henrys

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

$= \mu_0 N^2 \frac{A}{\ell}$

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

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

b) In 3.0 *seconds* the current in a particular RL circuit has increased to a value that is 50% of the maximum current possible. What is the time constant of this RL circuit?

I) 6.0 seconds
II) 0.50 seconds
III) 4.3 seconds
IV) 5.2 seconds
V) 0.23 seconds

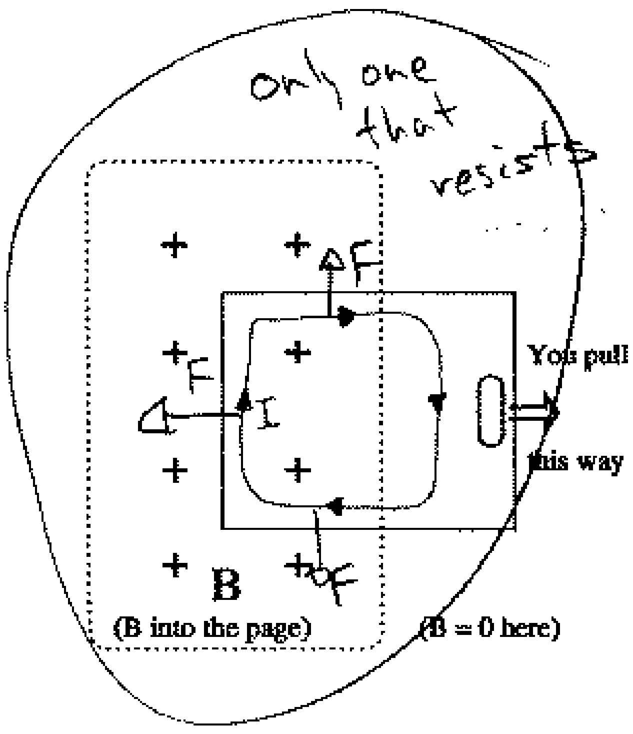
$.5 V_0 = V_0 (1 - e^{-t/\tau})$

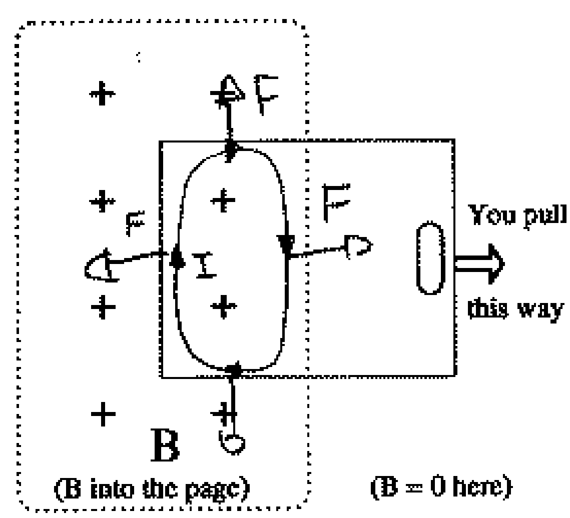
$.5 = e^{-3/\tau}$

$\ln(.5) = -3/\tau$

$\tau = -3/\ln(.5) = 4.33 s$

c) You are trying to pull a conductor through a magnetic field. Which drawing best descibes the path of the eddy currents that appear to resist your pulling.





1) Short Questions (continued)

d) A solar cell has a light gathering area of 10 cm^2 and produces 0.20 A at 0.80 V when illuminated with sunlight of intensity (Power/Area) of $|\vec{S}| = 1000\ W/m^2$. What percentage of the sunlight is converted into electrical power (i.e. what is the efficiency of the solar cell) ?

I) 16 %
II) 7.0 %
III) 23 %
IV) 4.0 %
V) 32 %

$P = IV = (0.20A)(0.80V) = .16W$

Incident power $= \left(1000 \frac{W}{m^2}\right)(10 cm^2)\left(\frac{1m}{100cm}\right)^2 = 1W$

$\frac{P}{inc.\ P} = \frac{.16W}{1W} = .16 \rightarrow 16\%$

e) Assume that the radiant energy from the sun strikes the earth as a self propagating electromagnetic wave of average intensity 1340 W/m^2. Choose the best peak (max) values of E and B for this wave.

lets try these, know $S_{av} = \frac{E_{max} B_{max}}{2\mu_0}$

I) 300 V/m, 10^{-4} T
II) 1000 V/m, 3.35×10^{-6} T
III) 225 V/m, 1.64×10^{-3} T
IV) 111 V/m, 3.01×10^{-5} T
V) 711 V/m, 2.36×10^{-6} T

$E_{max} = cB$

$S_{av} = \frac{c B_{max}^2}{2\mu_0}$

$B_{max}^2 = \frac{2\mu_0 S_{av}}{c}$

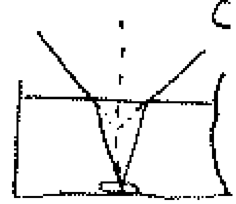
$B_{max} = \sqrt{\frac{2(4\pi \times 10^{-7})\frac{Tm}{A} 1340\frac{W}{m^2}}{3.0 \times 10^8 m/s}}$

$= 3.35 \times 10^{-6}\ T \Rightarrow E = 1005$ ✓

(note $\frac{N}{mA} = T$ & $\frac{Tm}{A}\ \frac{(N \cdot m/s)}{m^2} / \frac{m}{s} = \frac{N}{Am}$)

f) A coin is located at the bottom of a pan of water. Does refraction of light tend to make the coin appear to be deeper or shallower than its real depth?

DEEPER SHALLOWER



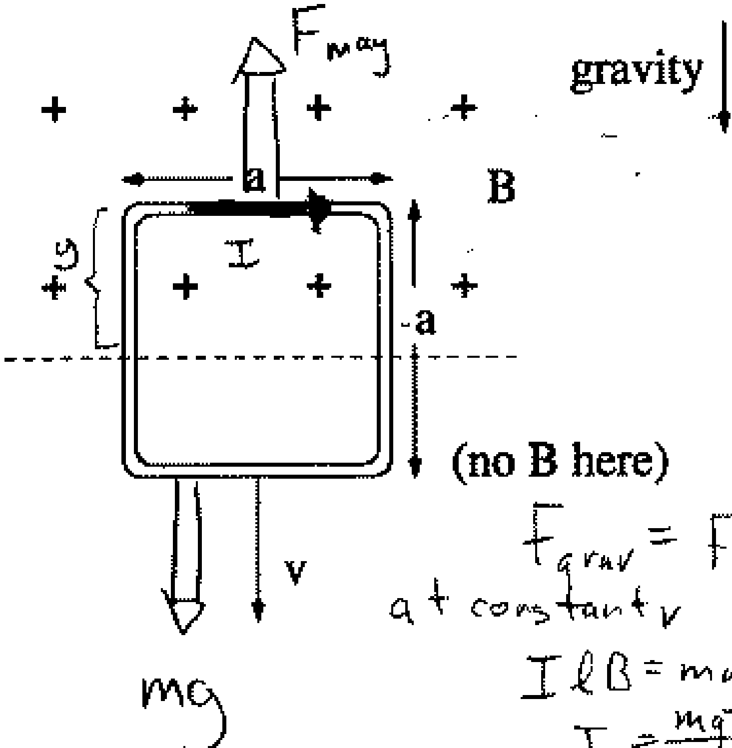
g) A laser beam passes from air to glass. What happens to the frequency of this light?

I) Increases
II) Decreases
III) Stays the same

no traffic jams

2) Induced EMF (15 points: 2 + 4 + 5 + 4)

In the figure below, the conducting loop has fallen a short distance and is now falling at a constant velocity, v. The loop has sides of length, a = 0.5 m, has a mass, M = 10.0 grams, and Resistance, R = 1.00 Ohms. If B = 2.50 T, directed into the page as shown, answer the following questions:



What force is pulling down on the loop?

$F = mg$

$= (.01\,kg)(9.8\,m/s^2)$

F= 0.098N (2)

Since the loop is moving at a constant velocity, there must be an equal force acting to hold the loop up. What current do you need to flow in the loop to produce this force? (indicate the I direction too)

$F_{grav} = F_{mag} = I \ell B = mg$

at constant v

$I \ell B = mg$

$I = \frac{mg}{\ell B} = \frac{0.098N}{(0.5m)(2.50T)}$

I = 0.078 A (4)

recall, $1T = 1 \frac{N}{Am}$

Since there is a resistance in this loop, you can calculate the induced EMF. This EMF is produced by the changing flux. By setting these equal to each other, you can calculate the constant velocity, v.

$V = \mathcal{E} = IR$

$= (0.0784A)(1.00\Omega) = 0.0784\,V$

v = 0.063 m/s (5)

$\mathcal{E} = -\frac{d\phi}{dt}$ $\quad \phi = Bay$

$\frac{d\phi}{dt} = Ba\frac{dy}{dt}$

$\left|\frac{dy}{dt}\right| = |v|$

$\left|\frac{d\phi}{dt}\right| = |Bav| = \mathcal{E}$

$v = \frac{\mathcal{E}}{Ba} = \frac{0.0784V}{2.5\frac{N}{Am}\,0.5m} = 0.06272\,\frac{Nm}{s}/N$

Power $= Fv = \mathcal{E}I$

$= mgv$

$v = \frac{(0.078A)(0.078V)}{0.098N}$

$= 0.062$ (ok)

If you couldn't solve for v that way, calculate how much power is supplied by gravity. This should be equal to the power generated by the current and the EMF in the loop. So, how much power is supplied by gravity?

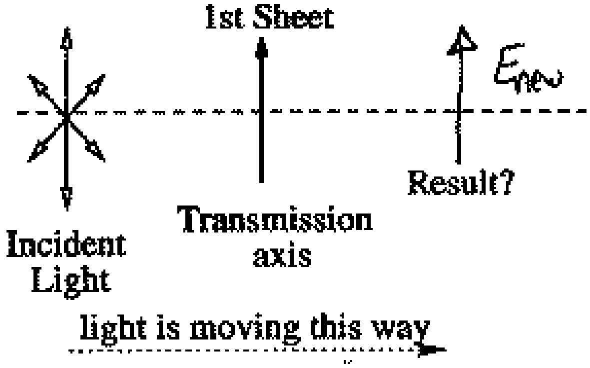
$P = mgv = \mathcal{E}I = (0.0784A) \times (0.0784V)$

$= 6.1 \times 10^{-3} W$

P = 6.1×10^{-3} W (4)

3) Polarization (10 points: 2 points + 4points + 4 points)

Initially unpolarized light of intensity I = 10.0 W/m^2 is incident on a polarizer with its transmission axis oriented as shown in the figure below. Indicate on the figure the direction of the transmitted E field after the light has passed through the polarizer. What is the intensity of this transmitted light?



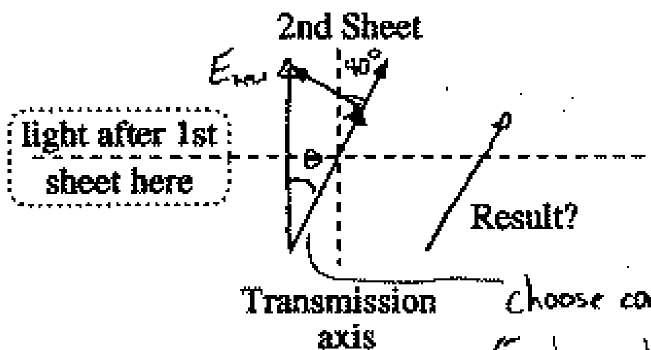
lose $\frac{1}{2}$ Incident intensity

I= $5.00 \frac{W}{m^2}$ **(2)**

$I_{new} = \frac{I_{unpolarized}}{2} = \frac{10.0 W/m^2}{2}$

$= 5.00 W/m^2$

The light that passed through the first polarizer is then incident on a second sheet of polarizer. The second sheet has it's transmission axis oriented at 40 degrees from the vertical direction. (you must use your result from above, or choose a direction for the E field if you had no answer) Indicate the direction of the E field after passing through this second sheet of polarizer. What is the intensity of the light that passed through the second polarizer?



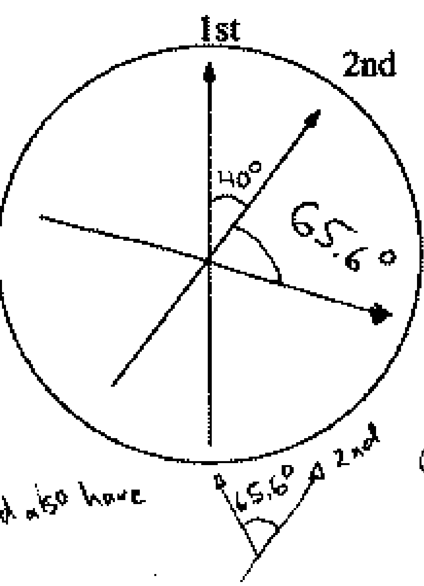
I= $2.93 \frac{W}{m^2}$ **(4)**

$I_{pass} = 5.00 \frac{W}{m^2} \cos^2 40°$

$= 2.93 \frac{W}{m^2}$

choose component of E along the trans axis $= E_{new} \cos\theta$ & $I_{pass} = \left(\frac{I_0}{2}\right) \cos^2 40°$ (From above)

Now, you want to place a third sheet of polarizer after the 2nd sheet so that the final intensity of the light after the third sheet of polarizer is 1/20th of the original intensity. At what angle should you place this third polarizer. Indicate the direction of the 3rd transmission axis on the figure below.



could also have

3rd = ?

Want angle between 2nd & 3rd polarizer to be such that θ_{23}

Angle = $65.6°$ **(4)**

(Be sure you defined it correctly on the figure)

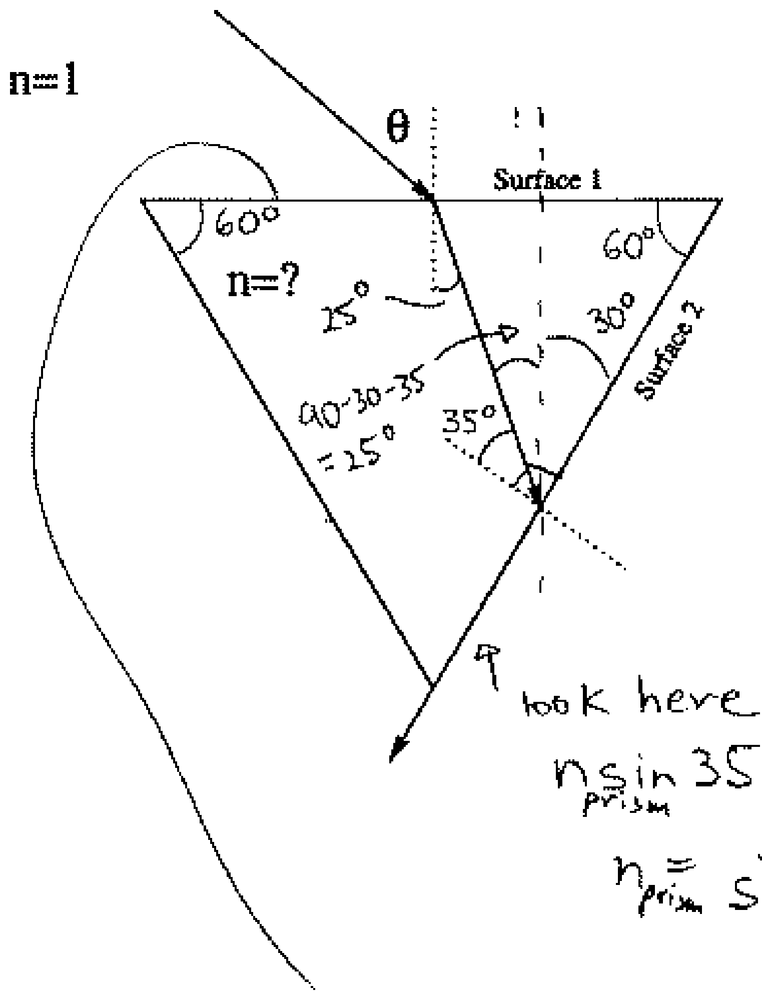
$I_{final} = \frac{10 W/m^2}{20} = 2.93 \frac{W}{m^2} \cos^2\theta_{23}$

$\cos\theta_{23} = \sqrt{\left(\frac{10 W/m^2}{20}\right) \frac{1}{2.93 \frac{W}{m^2}}} = 0.413$

$\theta_{23} = 65.6°$ $\qquad \theta_{23} = \cos^{-1}(0.413)$

4) Critical Angle (10 points, 5 points each)

The light beam strikes Surface 2 at the critical angle.



Determine the angle that light entered the prism.

θ= 47.3°

Determine the index of refraction of the prism.

n = 1.74

$n_{prism} \sin 35° = 1 \sin 90°$

$n_{prism} = \frac{1}{\sin 35°} = 1.74$

look here

$1 \sin\theta = 1.74 \sin 25°$

$\theta = \sin^{-1}(1.74 \sin 25°)$

$= 47.3°$