Physics 116b Test 3 November 08, 2007

Name:________________ 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	20	
2	EM waves, Polarization	10	
3	Lenses, Mirrors	14	
Total		44	

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

d) Estimate the force on the Earth due to the light emitted by the sun. The average intensity of solar energy at the earth is around 1200 W/m^2, and the radius of the earth is 6371 Km. (4 pts) Why isn't the earth blown off course by this force (try to be semi-quantitative to back up you assertions)? (2 pts)

Intensity $\frac{N\,m}{m^2\,s}$ so Press $= I/c$

assume earth absorbs most

$F_{force} = PA = 1200\,\frac{W}{m^2} \cdot (6.371\times10^6 m)^2\,\pi / 3.0\times10^8\,\frac{m}{s}$

$= 5.1\times10^8 N$

Force~ $5.8\times10^8 N$

estimate

$m_e \sim (1000\,\frac{kg}{m^3})\,\frac{4}{3}\pi\,(6.371\times10^6 m)^3 = 10^{24} kg$

$F_{sun} \sim mr\omega^2 \sim 10^{24} kg\,(1.5\times10^{11} m)\,(2\pi\,(\frac{1}{\pi\times10^7 s}))^2$ (about 8.2 min; 1 yr)

or $\sim 10^{22} N$ much bigger!

e) An L-R-C series circuit draws 200 W from a 120V (rms) 50.0 Hz ac line. The power factor ($\cos\varphi$ term) for this circuit is 0.670 and the source voltage leads the current. What is the resistance R of the circuit? (4 pts) What capacitance should be added to make the power factor unity? (2 pts)

$P_{avg} = V_{rms} I_{rms} \cos\phi$ $\qquad \phi = \cos^{-1}(0.670) = 47.93°$

$I_{rms} = V_{rms}/Z \qquad \cos\phi = R/Z$

$Z = \frac{V_{rms}^2}{P_{avg}} \cos\phi \qquad R = \frac{V_{rms}^2}{P_{avg}} \cos^2\phi$

$= \frac{(120V)^2}{200W} (.670)^2$

R= $32.32\,\Omega$
C= $88.7\,\mu F$

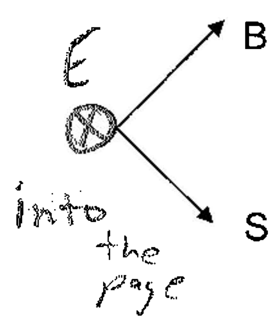
Since voltage leads, L is dominant, add C until $\omega L - \frac{1}{\omega C} = 0$ or $\phi = 0$

$\left|\left(\omega L - \frac{1}{\omega C}\right)\right| = |R\tan\phi| = \frac{1}{\omega C_{new}}$

$C_{new} = 1/\omega R\tan\phi = 2\pi\,\frac{50}{s}\,32.32\tan 48$

$= 8.87\times10^{-5} F$

f) In which direction is the Electric field pointing? (2 pts)



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

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

$$\vec{E}(y,t) = E_0 \sin\left(\frac{1.25e7}{m} y - \frac{3.75e15}{s} t\right)\hat{k}$$

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

direction = $\hat{j}$

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)

direction = $\hat{i}$

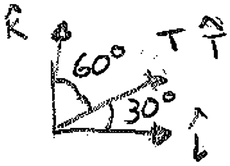
To reduce the Electric Field by a factor of 2 with a sheet of polarizing material, in which direction should the transmission axis of a single polarizer be placed? (More than one answer will work, you need supply only one answer)
(4 pts)

$\frac{1}{2} = \cos\theta$

$\theta = 60^\circ$

must be in $\hat{i}\hat{k}$ plane

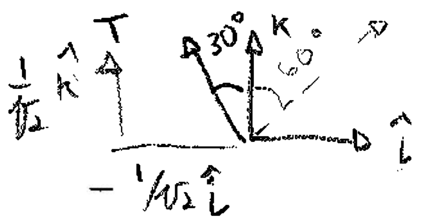
$\hat{T} = \cos 45^\circ \hat{i} + \sin 45^\circ \hat{k}$



direction = ($\sqrt{3}/2$) i
(0) j
(0.5) k

To reduce the Electric Field to zero, in which direction should I place the transmission axis of a second polarizer, placed after the first polarizer? (More than one answer will work, you need supply only one answer)
(2 pts)

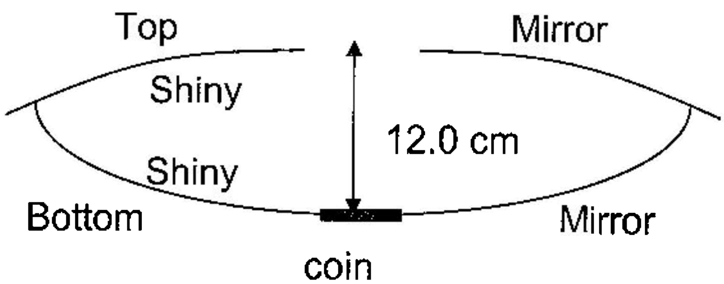
need @ 90° to 1st polarizer
(−45° is easy to to)



direction = (0.5) i
(0) j
($-\sqrt{3}/2$) k

3) Lenses, Mirrors, Magic (Show your work!)

A popular optical illusion uses 2 concave spherical mirrors separated by 12.0 cm as shown. The top mirror, which has a hole in the center, has a radius of curvature of 21.8 cm. The bottom mirror has a radius of curvature of 26.0 cm. If a coin is placed on the surface of the bottom mirror, where is an image formed from these 2 mirrors with respect to the lower mirror? (8 pts) What is the overall magnification (4 pts), and is this image real or virtual (2 pts)? Hint: Do this in 2 steps, using the mirror with the hole in the first step. The hole is just there to let you see what happens, it won't affect the performance of the mirror for the purposes of this problem.



Location = 11.59 cm above
Overall M = −1.075

1st step image from top mirror

$$f = \frac{21.8\text{cm}}{2} = 10.9\text{cm}$$

$$s_1' = 1\Big/\left(\frac{1}{f_1} - \frac{1}{s_1}\right) = 1\Big/\left(\frac{1}{10.9\text{cm}} - \frac{1}{12.0\text{cm}}\right) = 118.909\text{cm}$$

2nd step image from bottom mirror

118.909 cm below top mirror is −106.909 cm behind bottom mirror $s_2 = -106.909$

$$s_2' = 1\Big/\left(\frac{1}{\left(\frac{26.0\text{cm}}{2}\right)} - \frac{1}{-106.909}\right) = 11.59\text{ cm above bottom mirror}$$

f_2

$$M_{tot} = m_1 \cdot m_2 = \left(-\frac{s_1'}{s_1}\right)\left(-\frac{s_2'}{s_2}\right) = \left(-\frac{118.909}{12.0\text{cm}}\right)\left(-\frac{11.59\text{cm}}{-106.909}\right)$$

$$= -1.075$$

s_1' is a real image & bottom mirror makes it focus sooner

real & inverted