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Midterm #2
Physics 1C
Prof. David Saltzberg
March 2, 2011

Time: 50 minutes

Closed Notes. Closed Book. One 3"x5" index card with notes on both sides is allowed (plus the one from MT1). Calculators are allowed.

If a problem is confusing or ambiguous, notify the professor

Clarifications will be written on the blackboard. Check the board.

This exam is version B. Show your work.

There are 8 pages including this cover sheet. Make sure you have them all.

Problem	Points
1	8 /12
2	11 /12
3	12 /12
4	12 /12
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TOTAL	43 /48

Useful(?) constants etc.

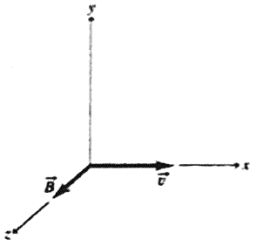
$\mu_0 = 4\pi \times 10^{-7}$ Wb/(A-m) $c = 3.00 \times 10^8$ m/s
$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N-m^2)
Order of <1 SI prefixes by ×1000: yocto, zepto, atto, fempto, pico, nano, micro, milli
Order of >1 SI prefixes by ×1000: kilo, Mega, Giga, Tera, Peta, Exa, Zetta, Yotta, Hella

1) Multiple Choice (2 pts each)

a) You take your US hair dryer to Europe, where the electrical plug is put out 240V(rms) instead of the 120 V(rms) in the United States. The transformer you need to run has N_1 coils on the input and N_2 coils on the output to the dryer. Their ratio is:

A) $N_1/N_2 = 50/60$
B) $N_1/N_2 = (50/60)^2$
C) $N_1/N_2 = 1/2$
D) $N_1/N_2 = 2$
E) $N_1/N_2 = 1$

b) In the diagram below

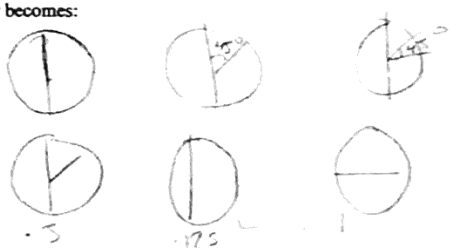


The direction of the amplitude magnetic field in a linearly polarized propagating electromagnetic wave is shown as **B**. The direction of propagation is also shown as **v**. The electric field at this point in space and time points along what direction?

A) -z axis
B) +y axis
C) -y axis
D) +x axis
E) -x axis

c) In class we set up 3 polarizing filters each with a polarization axis rotated at +45 degrees with respect to the one before, so that the intensity of unpolarized light hitting the first filter was reduced to 1/8 its original intensity after it passed through the third. When we change the order of the first and second polarizing filters, the fraction of the original intensity leaving the third filter becomes:

A) 1/8
B) 1/4
C) 0
D) 1/2
E) 1/(2sqrt(2))



d) A convex lens has a focal length of 20cm. An object is placed 30cm from its vertex. The image is:

A) ~~erect and virtual~~
B) inverted and real
C) ~~erect and real~~
D) inverted and virtual
E) not formed

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

$f = \frac{R}{2}$ $\quad \frac{1}{s'} = \frac{1}{20} - \frac{1}{30} = \quad s' = 60$

e) A slab of glass is surrounded by air on all sides. A light ray propagating in the glass strikes one of the surfaces of the glass at an incident angle of 40° relative to the normal. Most of this light is refracted into the air. You can conclude about the index of refraction:

A) it is less than or equal to sin(40°)
B) it is more than or equal to sin(40°)
C) it is less than or equal to 1/sin(40°)
D) it is more than or equal to 1/sin(40°)

$\frac{n'}{y} = \frac{-s'}{s}$

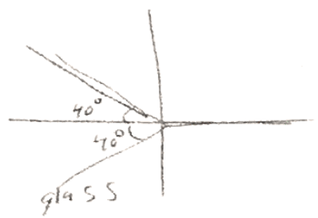
f) Unpolarized light propagates along the optic axis of a crystal. Which is true?

A) One polarization of light propagates faster than the other
B) The light only propagates if the electric field is aligned with the optic axis
C) Both polarizations propagate at the same speed

$n_2 \sin 40° = n_b \sin b$

$\sin 40° = n_b \sin b$

53.4
51.12



$n_g \sin 40° = 1$

$n_g = \frac{1}{\sin 40°}$

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2) An electomagnetic wave travels in vacuum has an electric field given with a magnitude $E(x,t) = (10 V/m)\sin(k*x - (2.0\times10^{14}\ rad/s)\ t)$.

a) (4 pts) What is the wavelength of the wave?

$E_{max} = 10 \frac{V}{m}$

$c = v = \lambda f$

$E(t,t) = E_{max} \cos(kx - \omega t)$

$\lambda = \frac{c}{f} = \frac{3\times10^8 m/s}{3.18\times10^{13} 1/s} = 9.42\times10^{-6} m$

$\omega = 2\times10^{14}\ rad/s = 2\pi f$

$f = \frac{\omega}{2\pi} = \frac{2\times10^{14}\ rad/s}{2\pi} = 3.18\times10^{13}\ Hz$

b) (4 pts) What is the amplitude of the wave corresponding to the magnetic field? (give your answer in SI units.)

$E = cB$ $\quad B =$

$\frac{10 \frac{V}{m}}{3\times10^8 m/s} = 3.33\times10^{-8} \frac{V}{s}\frac{1}{m} T = J/s = kg\cdot m/s^2/s$

c) (4 pts) If this plane wave impinges on black paper and is absorbed by it over its entire area. What is the pressure on the paper? (has to be absorbed ⊥ to plane for $\int \vec{S}\cdot d\vec{A}$)

$P_{rad} = \frac{S_{av}}{c}$ if absorbed

$S_{avg} = \frac{E\cdot B}{2\mu_0}$

$= \frac{E\cdot B}{2\mu_0 \cdot c} = \frac{10\times3.33\times10^{-8}}{2\times4\pi\times10^{-7}\times3\times10^8 m/s} = 7.12\times10^{-11}$ Pa

$\times -1$

$V = IR$ $\quad V = \Delta P = J$

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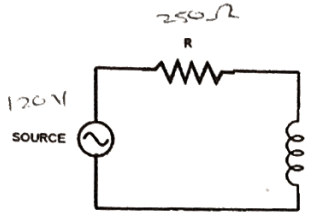
3) An AC voltage socket produces a sinusoidal output at 60 Hz and an amplitude of 120V. This output is connected in series with a 250Ω resistor and 500 mH inductor. At this frequency:



$f = 60\ Hz \quad 120\pi$

no resistance

$= .5H$

a) (5 pts) What is the voltage amplitude across the inductor?

$V_L = I \cdot X_L = I\omega L = \dfrac{V}{\sqrt{R^2 + X_L^2}} \cdot \omega L$

what is I ?

$V = IZ$

$I = \dfrac{V}{Z} = \dfrac{V}{\sqrt{R^2 + X_L^2}} = \dfrac{120}{3.13 \times 10^2} = .38\ A$

$Z = \sqrt{R^2 + (X_L)^2} = 3.13 \times 10^2$

$= .38 \times 2\pi \times 60 \times .5 = 72\Omega$

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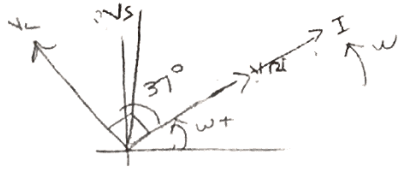
(3 continued)

b) (5 pts) Draw the phasor diagram indicating the current, I, and the voltages across the source (V_S), inductor (V_L) and resistor (V_R). . (For simplicity you do not need to indicate the values of the voltages and current.) Give the numerical value by which the voltage leads the current.

$\tan\phi = \dfrac{\omega L}{R}$

$\phi = \arctan\left(\dfrac{\omega L}{R}\right) = 37^\circ$



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4) An object 0.5 cm tall is placed 25 cm from the vertex of a concave mirror. The radius of curvature of the mirror is 10cm.

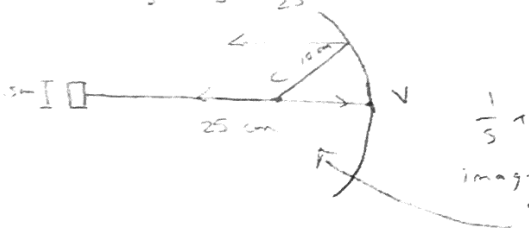
a) (4 pts) What is the position of the image (specify if it is in front or behind the mirror)

$s = 25\text{ cm}$ $\quad f = R/2 = 10\text{ cm}/2 = 5\text{ cm}$

$\frac{1}{25} + \frac{1}{s'} = \frac{1}{5}$

$\frac{1}{s'} = \frac{1}{5} - \frac{1}{25}$

$s' = 6.25\text{ cm}$



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

image is on same side as ant going to the left in my drawing so it is in front

b) (4 pts) What is the size of the image?

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

$y' = y \cdot \frac{-s'}{s} = -.5\text{ cm} \cdot (-1)\frac{(6.25\text{ cm})}{(25\text{ cm})}$

$= +1.25 \times 10^{-1}$

image is inverted

(4 continued)

c) (4pts) A curved mirror produces an inverted image of an object. Draw the mirror and where the object is relative to its focal point.