Physics 201 Name KEY

52

Exam 3 – Electrodynamics

April 5, 2007

This is a closed book examination. There is extra scratch paper available. Please explain your answers. Your explanation is worth 3/4 of the points on multiple-choice questions.

1) [4 PTS] What is the voltage at t = 0.3 s for a sinusoidal voltage source with V_{rms}= 4.0 V and f = ¼ Hz? Note: V(t=0s) = 0 V. WRITE OUT THE EQUATION.

a) 0.30 ± .02 V
b) 0.42 ± .02 V
c) 1.81 ± .02 V
[✓ d)] 2.57 ± .02 V
e) 5.27 ± .02 V

$V(t) = 4\sqrt{2} \sin\left(2\pi \frac{1}{4} t\right)$

set t = 0.3 sec

2) [4 PTS] A positively charged object is placed in the center of a room with a uniform magnetic field. If the magnetic field is pointing east the object will

a) move east.
b) move west.
c) move north.
d) move south.
[✓ e)] not move.

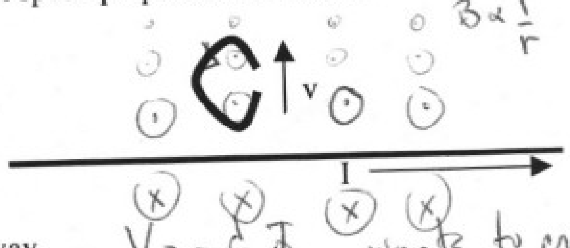
3) [4 PTS] A 1.5 V battery is connected to a transformer on a side with 1000 windings. The other side has only 10 windings so the output voltage is

a) 150 V
b) 15 V
[✓ c)] 0 V
d) 0.15 V
e) 0.015 V

$\frac{V_P}{N_P} = \frac{V_S}{N_S}$ is true for AC systems

$V = -N \frac{d}{dt} \Phi_m$

4) [4 PTS] A wire bent into a "C" shape moves at a constant speed perpendicular to (and away from) a long straight current-carrying wire.



a) The induced current in the loop will progress clockwise.
b) The induced current in the loop will progress counterclockwise.
[✓ c)] There will be no induced current.
d) The induced current decrease as the loop moves away
e) None of the above

$V = -\frac{c}{dt} \Phi_m$ wants to create B to replace the decreasing ~~smaller~~ Φ_m

Ring is not complete - hence no circuit and no current

5) [4 PTS] When the effective (rms) voltage and current in an ac circuit are in-phase, we know

[✓ a)] the total reactance is zero
b) the capacitive reactance is zero
c) the inductive reactance is zero
d) the resistance is zero
e) the impedance is zero
f) both (b) and (d)

$Z = (R^2 + (X_L - X_C)^2)^{1/2}$

$V = ZI$ and Z has no phase

$Z = R \rightarrow$ when $X_L - X_C = 0$

So $V = IR$ "resonance"

6) [4 PTS] An inductor and resistor are connected in series to an AC voltage source. If you double the frequency of the voltage the effect on the inductor is to

[✓ a) double its reactance]
b) increase its reactance by a factor of four
c) leave its reactance unchanged
d) halve its reactance
e) decrease its reactance by a factor of four

$X_L = \omega L$
where $V(t) = V_0 \sin(\omega t)$
$\omega' = 2\omega$
$X_L' = 2\omega L = 2X_L$

7) [4 PTS] If you double the current passing through an inductor, the energy stored in the inductor

[✓ a) increases $E_i = \frac{1}{4}E_f$]
b) increases $E_i = \frac{1}{2}E_f$
c) does not change.
d) decreases $E_i = 2E_f$
e) decreases $E_i = 4E_f$

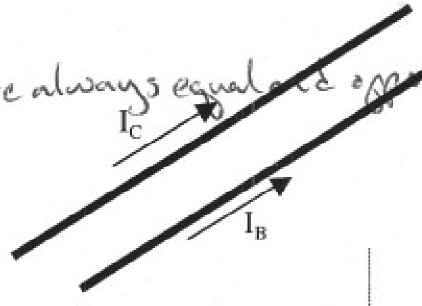
$E_i = \frac{1}{2} L I_i^2$
$I_f = 2I_i$
$E_f = \frac{1}{2} L (2I_i)^2 = \frac{1}{2} L 4I_i^2$
$E_f = 4\frac{1}{2} L I_i^2 = 4E_i$

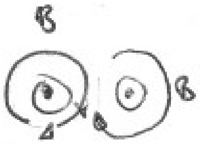
from $P = VI$ $\quad V = L\frac{dI}{dt}$ for $\frac{dL}{dt} =$
$P = \frac{dE}{dt} = L\frac{dI}{dt}I = L\frac{1}{2}\frac{d}{dt}I^2$
$\frac{d(E)}{dt} = \frac{d}{dt}\left(\frac{1}{2}LI^2\right)$

8) [4 PT] Two very long wires, 45 cm apart, are hung parallel to each other. Current flows down each wire in the same direction. Wire C has a current of 2 Amps and wire B has a current of 4 Amps.

a) The two wires are attracted $F_C = \frac{1}{4}F_B$
b) The two wires are attracted $F_C = \frac{1}{2}F_B$
[✓ c) The two wires are attracted $F_C = F_B$]
d) The two wires are repelled $F_C = F_B$
e) The two wires are repelled $F_C = 2F_B$
f) The two wires are repelled $F_C = 4F_B$

Forces are always equal and opposite!

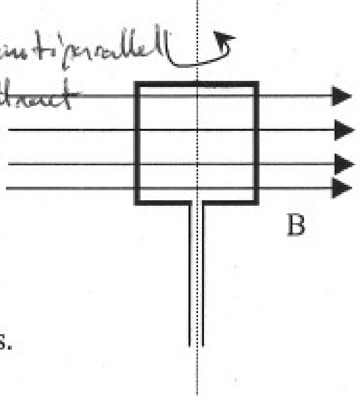




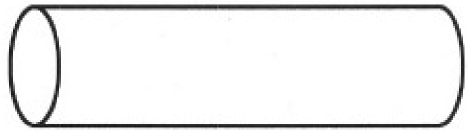
B fields antiparallel
↓↑ so attract

9) [10 PT] A square loop of wire is placed in a uniform magnetic field, B=1.5 T. The loop has sides that are 2 cm and is rotated at 2 Hz perpendicular to the magnetic field. Two leads connect to the loop.

a) What is the maximum magnetic flux in the loop?
b) Graph the voltage generated across the leads as a function of time.
c) List (at least) two ways you could increase the voltage across the leads.



10) [10 PT] A solid silver wire of diameter 2 mm carries a current of 10 mA. The current density is constant and uniform. Using Ampere's Law graph the magnetic field inside and outside the wire.



Useful mathematical relationships:

$\sin^2(\theta) + \cos^2(\theta) = 1$ and $\sin(2\theta) = 2\sin(\theta)\cos(\theta)$

$\cos(2\theta) = \cos^2(\theta) - \sin^2(\theta) = 2\cos^2(\theta) - 1 = 1 - 2\sin^2(\theta)$

$\int_b^c \frac{a}{x} = a\ln x\Big|_b^c = a[\ln c - \ln b] = a\ln\left(\frac{c}{b}\right)$

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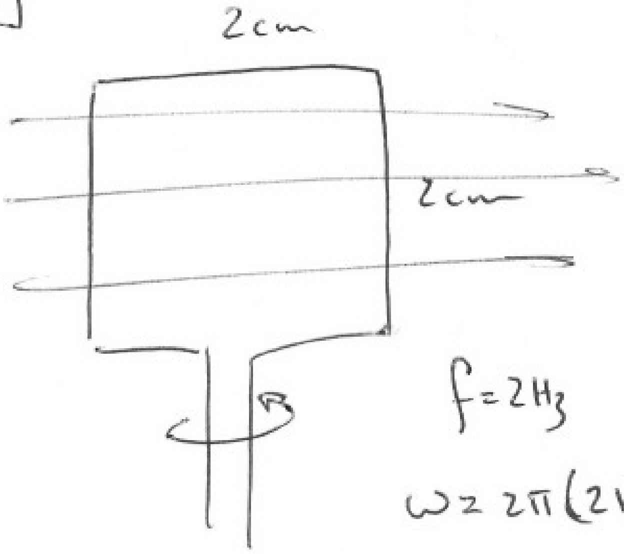


$B = 1.5T \quad A = (.02)^2\ m^2$

$\Phi_m = \int \vec{B} \cdot d\vec{A} = BA\cos(\omega t)$

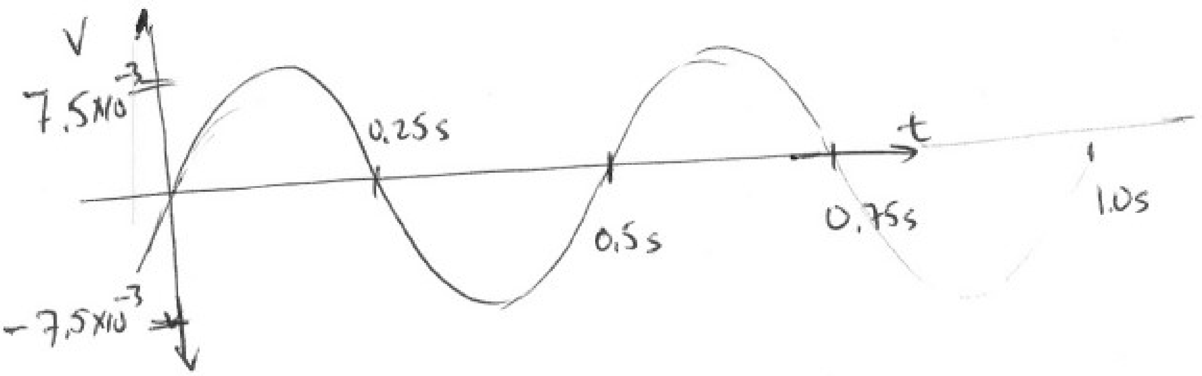
$f = 2Hz$

$\omega = 2\pi(2Hz)$

(a) $\underset{(\cos(\omega t)=1)}{\Phi_{max}} = 1.5T \cdot (.02)^2 m^2 = .0006\ Tm^2 = 6\times10^{-4}\ Tm^2$

(b) $V = -\frac{d}{dt}\Phi_m = \frac{-d}{dt} BA\cos(\omega t) = {}^{+}BA\sin(\omega t)\cdot\omega$

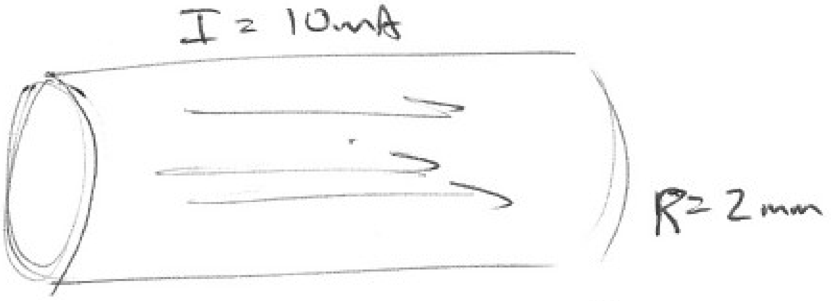
$V = .0075\ V\sin(\omega t) = 7.5\times10^{-3}\sin(\omega t)\ V$



(c)
- Increase frequency (ω)
- Increase Area (A)
- Increase magnetic field (B)

(sort of cheating) • Increase Number of loops (N) $V = -N\frac{d\Phi_m}{dt}$

$\boxed{10}$



$$J = \text{constant} = \frac{I}{A}.$$

Ampere's Law

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 \overset{\text{enclosed}}{\Sigma I}$$

$A = \pi(.002)^2$

Inside wire

Note: $dl = r\,d\theta$
$dA = r\,dr\,d\theta$

$$\oint_0^{2\pi} \vec{B}\circ d\vec{l} = \mu_0 \oint \overset{\text{constant}}{J}\, dA = \mu_0 J \int dA$$

$$B\,2\pi r = \mu_0 J\,\pi r^2 = \mu_0 \frac{I}{\pi R^2}\pi r^2$$

$$B = \frac{\mu_0}{2\pi}\frac{I}{R^2}r$$

Outside Wire

$$\oint_0^{2\pi} B\cdot dl = \mu_0 I$$

$$B\,2\pi r = \mu_0 I$$

$$B = \frac{\mu_0}{2\pi}\frac{I}{r}$$