TIME OF COMPLETION SOLUTION NAME________________________

DEPARTMENT OF NATURAL SCIENCES

PHYS 1112, Exam 2
Version 1
Total Weight: 100 points

Section 1
March 21, 2002

1. Check your examination for completeness prior to starting. There are a total of eleven (11) problems on nine (9) pages.

2. Authorized references include your calculator with calculator handbook, and the Reference Data Pamphlet (provided by your instructor).

3. You will have 80 minutes to complete the examination.

4. The total weight of the examination is 100 points.

5. There are six (6) multiple choice and five (5) calculation problems. Work 4 out of 5 calculation problems. Show all work; partial credit will be given for correct work shown.

6. If you have any questions during the examination, see your instructor who will be located in the classroom.

7. Start: 10:30 a.m.
Stop: 11:50 a.m

PROBLEM	POINTS	CREDIT
1-6	30	
7	15	
8	20	
9	20	
10	20	
11	15	
	TOTAL	

CIRCLE THE **SINGLE** BEST ANSWER FOR ALL MULTIPLE CHOICE QUESTIONS. IN MULTIPLE CHOICE QUESTIONS WHICH REQUIRE A CALCULATION SHOW WORK FOR PARTIAL CREDIT.

1. A straight length of current-carrying wire is in a uniform magnetic field. If the wire does not experience a force,

   a. Everything is as it should be.

   [✓ b.] It must be parallel to the magnetic field.

   c. We have an impossible situation.

   d. The wire must be perpendicular to the magnetic field.

$$F = BI\ell \sin\theta$$

$$F = 0 \Rightarrow \sin\theta = 0$$

$$\underline{\underline{\theta = 0^\circ}}$$

2. An electron which moves with the speed of 3.00×10^4 m/s parallel to a uniform magnetic field of 0.400 T experiences a force of what magnitude? ($q_e = 1.60 \times 10^{-19}$ C)

   a. 4.80×10^{-14} N.

   b. 19.2×10^{-16} N.

   c. 2.20×10^{-24} N.

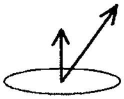
   [✓ d.] Zero.

$$F = q \cdot v \cdot B \cdot \sin\theta$$

$$\theta = 0^\circ \Rightarrow$$

$$\underline{\underline{F = 0}}$$

3. A uniform 1.50 T magnetic field passes through the plane of a wire loop 0.300 m^2 in area. What flux passes through the loop when the direction of the 1.50 T field is at a 30° angle to the normal of the loop plane?



$$\Phi = BA \cdot \cos\theta$$

$$\Phi = 1.50T \cdot 0.300m^2 \cdot \cos 30^\circ$$

$$\underline{\underline{= 0.390\ Wb}}$$

a. 5.00 Wb.

b. 0.520 Wb.

[✓ c.] 0.390 Wb.

d. 0.225 Wb.

4. A radio wave signal which transmits at a frequency of 7.20 MHz has what wavelength?

[✓ a.] 41.7 m.

b. 4.20 m.

c. 28.8 m.

d. 2.40 x 10^{-2} m.

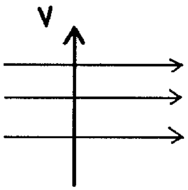
$$c = f \cdot \lambda$$

$$\lambda = \frac{c}{f}$$

$$\lambda = \frac{3 \times 10^{8} m/s}{7.20 \times 10^{6}\ 1/s} = 0.417 \times 10^{2} m$$

$$\underline{\underline{= 41.7 m}}$$

5. A proton moves through the constant magnetic field as shown below. What is the direction of the magnetic force acting on it?



a. To the left.

b. To the right.

[✓ c. Into the page.]

d. Out of the page.

6. In an ac series circuit, the voltage in a pure inductor differs in phase with the current by what angle?

a. Zero.

b. 45°.

[✓ c. 90°.]

d. 180°.

7. You have an inductor with an inductance of 75.0 mH.

a. At what rate must the current change in the inductor to secure a potential difference across the inductor equal to 3.00 V? (*Hint: you need to find ΔI/Δt.*)

$$\mathcal{E} = -L \frac{\Delta I}{\Delta t}$$

$$\frac{\Delta I}{\Delta t} = -\frac{\mathcal{E}}{L}$$

$$\frac{\Delta I}{\Delta t} = -\frac{3.00 V}{75.0 \times 10^{-3} H}$$

$$= -0.04 \times 10^{3} A/s$$

$$= \underline{\underline{-40.0 A/s}}$$

b. Should you have the current increasing or decreasing with time?

DOESN'T REALLY MATTER => ONLY AFFECTS POLARITY, NOT THE MAGNITUDE OF $\mathcal{E}$!

c. At the moment you have an electric current of 3.00 A going through the inductor, what is the amount of energy stored in it?

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

$$PE_L = \frac{1}{2} \cdot 75.0 \times 10^{-3} H \cdot (3.00 A)^2$$

$$= 337.5 \times 10^{-3} J$$

$$= \underline{\underline{0.338 J}}$$

8. A solenoid has 2000 turns of wire and is 125 cm long and 10.0 cm in diameter. A circular wire loop of diameter 5.00 cm lies along the axis of the solenoid near the middle of its length as shown below.

$$n = \frac{2000}{1.25\,m}$$

$$= 1600\,m^{-1}$$

a. If the current in the solenoid initially is 4.00 A, find the magnetic field inside the solenoid.

$$B = \mu_0 n I$$

$$B = 4\pi \times 10^{-7}\,\frac{Tm}{A} \cdot 1600\,m^{-1} \cdot 4.00\,A$$

$$= 80425 \times 10^{-7}\,T$$

$$= \underline{\underline{0.008\,T}}$$

b. Find the magnetic flux through the smaller loop.

$$\Phi = B \cdot A = 0.008\,T \cdot 0.002\,m^2 = 0.0000157\,Wb$$

$$= \underline{\underline{1.57 \times 10^{-5}\,Wb}}$$

$$A = \pi r^2 = \pi \cdot (0.025\,m)^2 = 0.002\,m^2$$

c. If the current in the solenoid is switched off and falls to zero in 2.00 s, calculate the average value of the *emf* induced in a smaller loop.

$$\Phi_i = 1.57 \times 10^{-5}\,Wb$$

$$\Phi_f = 0 \qquad \Delta\Phi = -1.57 \times 10^{5}\,Wb$$

$$\mathcal{E} = -N\,\frac{\Delta\Phi}{\Delta t} = -1 \cdot \frac{(-1.57 \times 10^{-5}\,Wb)}{2.00\,s}$$

$$= \underline{\underline{7.85\,\mu V}}$$

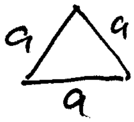
9. A 40.0-cm length of wire carries a current of 20.0 A. It is bent into a loop and placed with its normal perpendicular to a magnetic field with a strength of 0.520 T. What is the torque on the loop if it is bent into

a. An equilateral triangle?

$\tau = NBIA \sin\theta$ $\quad \sin\theta = 1$

$N = 1 \Rightarrow$

$\boxed{\tau = B \cdot I \cdot A}$



$a = \frac{0.400m}{3} = \underline{0.1333m}$

$A = 0.00764m^2$

$\tau = 0.520T \cdot 20.0A \cdot 0.00764m^2$

$= \underline{\underline{0.0795Nm}}$

b. A square?

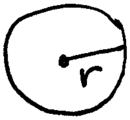
$a = 10.0\,cm = 0.1m$

$A = 0.01m^2$

$\tau = 0.520T \cdot 20.0A \cdot 0.010m^2$

$= \underline{\underline{0.104\,N \cdot m}}$

c. A circle?



$0.4m = 2\pi r \Rightarrow r = 0.0637m$

$A = \pi r^2 = \pi(0.0637m)^2 = 0.0127m^2$

$\tau = 0.520T \cdot 20.0A \cdot 0.0127m^2 = \underline{\underline{0.132\,N \cdot m}}$

d. Which torque is the greatest?

CIRCLE

10. A series LCR circuit contains a 1.00-μF capacitor, a 5.00-mH coil, and a 100-Ω resistor. It is connected to an *ac* source which provides the maximum voltage output of 200 V and operates at a frequency of 100 Hz.

a. What is the impedance of the circuit?

$$X_L = 2\pi \cdot 100\,Hz \cdot 5.00\times10^{-3}\,H$$
$$= 3.14\,\Omega$$

$$X_c = \frac{1}{2\pi \cdot 100\,Hz \cdot 1\times10^{-6}\,F}$$
$$= 0.159\times10^{4}\,\Omega$$

$$z = \sqrt{R^2 + (X_L - X_c)^2}$$
$$= \sqrt{(100\Omega)^2 + (3.14 - 1590)^2\,\Omega^2}$$
$$= \underline{\underline{1590\,\Omega}}$$

b. Find the *rms* value of the current in the circuit.

$$\Delta V = \frac{\Delta V_M}{\sqrt{2}} = \frac{200\,V}{\sqrt{2}} = 141\,V$$

$$I = \frac{\Delta V}{z} = \frac{141\,V}{1590\,\Omega} = \underline{\underline{0.0889\,A}}$$

c. What is the phase angle between the instantaneous current and the instantaneous voltage across the combination?

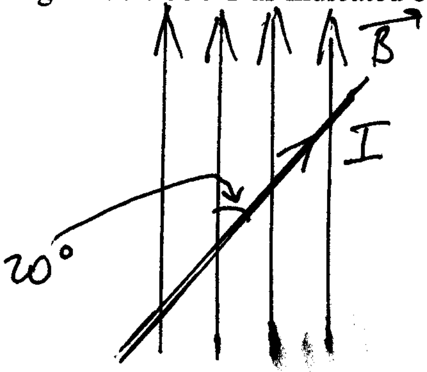
$$\tan\theta = \frac{X_L - X_c}{R} = \frac{3.14\,\Omega - 1590\,\Omega}{100\,\Omega} = -15.9$$

$$\theta = \tan^{-1}(-15.9) = \underline{\underline{-86.4^\circ}}$$

d. What is the *rms* power dissipated in the circuit?

$$P = I\,\Delta V \cdot \cos\Phi = 0.0889\,A \cdot 141\,V \cdot \cos(-86.4^\circ)$$
$$= \underline{\underline{0.787\,W}}$$

11. A wire of infinite length carries a current of 15.0 A in a uniform magnetic field of magnitude 0.550 T as indicated below.



a. Find the force on a one meter of the wire. (Specify both magnitude and direction.)

$$F = B I l \sin\theta$$

$$F = 0.550\,T \cdot 15.0\,A \cdot 1.00\,m \cdot \sin(20°)$$

$$\underline{\underline{= 2.82\,N}}$$ OUT OF THE PAGE

b. If the angle that the wire makes with the magnetic field is tripled, what happens to the direction of the force?

DOESN'T CHANGE :

BEFORE : OUT OF THE PAGE

AFTER : OUT OF THE PAGE

c. Is the magnitude of the force tripled? Explain your answer.

NO

REASON: FORCE IS NOT PROPORTIONAL TO THE <u>ANGLE</u>, BUT TO THE <u>SINE</u> OF ANGLE !