PHYSICS DEPARTMENT

PHY 2049, Fall 2012 Midterm 2 October 31, 2012

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

(1) Code your test number on your answer sheet (use 76–80 for the 5-digit number). Code your name on your answer sheet. Darken circles completely (errors can occur if too light). Code your student number on your answer sheet.

(2) Print your name on this sheet and sign it also.

(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work.

(4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don’t know.

(5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.

(6) Blacken the circle of your intended answer completely, using a number 2 pencil. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.

(7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, NOT what you circle here. Good luck!!!

>>>WHEN YOU FINISH <<<

Hand in the answer sheet separately.

Constants: \( e = 1.6 \times 10^{-19} \text{ C} \) \( m_p = 1.67 \times 10^{-27} \text{ kg} \) \( m_e = 9.1 \times 10^{-31} \text{ kg} \) \( \epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2 \)

\( k = 1/(4\pi \epsilon_0) = 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \) \( \text{nano} = 10^{-9} \) \( \text{micro} = 10^{-6} \) \( \text{pico} = 10^{-12} \) \( \mu_0 = 4\pi \times 10^{-7} \text{ H/m} \)

Sphere: \( A = 4\pi R^2 \) \( V = \frac{4\pi}{3} R^3 \)

1. An RLC circuit has a resistance of 200Ω and an inductance of 15 mH. Its oscillation frequency is 7000 Hz. At time \( t = 0 \) the current is 25 mA and there is no charge on the capacitor. After five complete cycles the current is:

(1) \( 2.3 \times 10^{-3} \text{A} \) 
(2) \( 2.5 \times 10^{-2} \text{A} \) 
(3) \( 1.8 \times 10^{-6} \text{A} \) 
(4) 0 
(5) \( 2.1 \times 10^{-4} \text{A} \)

2. An LC circuit has a capacitance of 30 µF and an inductance of 15 mH. At time \( t = 0 \) the charge on the capacitor is 10 µC and the current is 20 mA. The maximum current is:

(1) 20 mA 
(2) 35 mA 
(3) 25 mA 
(4) 18 mA 
(5) 42 mA

3. The diagram shows three equally spaced wires that are perpendicular to the page. The currents are all equal, two being out of the page and one being into the page. Rank the wires according to the magnitudes of the magnetic forces on them, from least to greatest.

(1) 1 and 3 tie, then 2 
(2) 2 and 3 tie, then 1 
(3) 3, 2, 1 
(4) 2, 1 and 3 tie 
(5) 1, 2, 3

4. The magnetic field at any point is given by \( \vec{B} = A \vec{r} \times \hat{k} \), where \( \vec{r} \) is the position vector of the point and \( A \) is a constant.

The net current through a circle of radius \( R \), in the xy plane centered at the origin is given by:

(1) \( 2\pi AR/\mu_0 \) 
(2) \( 4\pi AR^3/3\mu_0 \) 
(3) \( \pi AR^2/\mu_0 \) 
(4) \( \pi AR^2/2\mu_0 \) 
(5) \( 2\pi AR^2/\mu_0 \)
5. A rod with resistance $R$ lies across frictionless conducting rails in a constant uniform magnetic field $B$, as shown. Assume the rails have negligible resistance. The magnitude of the force that must be applied by a person to pull the rod to the right at constant speed $v$ is:

\[
\begin{align*}
(1) & \quad BLv/R \\
(2) & \quad BLv \\
(3) & \quad B^2L^2v/R \\
(4) & \quad 0 \\
(5) & \quad B^2Lxv/R
\end{align*}
\]

6. A proton executes helical motion in a uniform $B$ field at a frequency of 820 kHz. It moves at an angle of 30 degrees relative to the direction of the field. What is the magnitude of the $B$ field?

\[
\begin{align*}
(1) & \quad 0.11 \text{T} \\
(2) & \quad 0.17 \text{T} \\
(3) & \quad 0.054 \text{T} \\
(4) & \quad 0.017 \text{T} \\
(5) & \quad 0.34 \text{T}
\end{align*}
\]

7. A changing magnetic field pierces the interior of a circuit containing three identical resistors. Two voltmeters are connected to the same points, as shown.

\[
V_1 \text{ reads } 1 \text{ mV}. \quad V_2 \text{ reads:}
\]

\[
\begin{align*}
(1) & \quad 1/2 \text{ mV} \\
(2) & \quad 0 \\
(3) & \quad 2 \text{ mV} \\
(4) & \quad 1/3 \text{ mV} \\
(5) & \quad 1 \text{ mV}
\end{align*}
\]

8. An ac generator producing 10 V (rms) at 200 rad/s is connected in series with a 50-Ω resistor, a 400-mH inductor, and a 200-µF capacitor. The rms voltage (in volts) across the inductor is:

\[
\begin{align*}
(1) & \quad 6.7 \\
(2) & \quad 10.0 \\
(3) & \quad 2.5 \\
(4) & \quad 10.8 \\
(5) & \quad 3.4
\end{align*}
\]

9. An inductance $L$ and a resistance $R$ are connected in series to an ideal battery. A switch in the circuit is closed at time $0$, at which time the current is zero. The rate of increase of the energy stored in the inductor is a maximum:

\[
\begin{align*}
(1) & \quad \text{at the time } t = (L/R)ln2 \text{ after the switch is closed} \\
(2) & \quad \text{a long time after the switch is closed} \\
(3) & \quad \text{at the time } t = 2L/R \text{ after the switch is closed} \\
(4) & \quad \text{at the time } t = L/R \text{ after the switch is closed} \\
(5) & \quad \text{just after the switch is closed}
\end{align*}
\]

10. An $RLC$ series circuit has $L = 100$ mH and $C = 1\mu$F. It is connected to a 1000-Hz source emf is found to lead the current by 75°. The value of $R$ is:

\[
\begin{align*}
(1) & \quad 126 \Omega \\
(2) & \quad 15.6 \Omega \\
(3) & \quad 1750 \Omega \\
(4) & \quad 1810 \Omega \\
(5) & \quad 175 \Omega
\end{align*}
\]

11. The diagrams show three circuits consisting of concentric circular arcs (either half or quarter circles of radii $r$, $2r$, and $3r$) and radial segments. The circuits carry the same current. Rank them according to the magnitudes of the magnetic fields they produce at C, least to greatest.

\[
\begin{align*}
(1) & \quad 1, 3, 2 \\
(2) & \quad 3, 2, 1 \\
(3) & \quad 2, 3, 1 \\
(4) & \quad 1, 2, 3 \\
(5) & \quad 2, 1, 3
\end{align*}
\]
12. Consider the mechanical system consisting of two springs and a block, as shown. Which one of the five electrical circuits is the analog of the mechanical system?

(1)  
(2)  
(3)  
(4)  
(5)  

13. A magnetic field is perpendicularly incident through a circle of wire with resistance $R$. The magnetic field varies in strength as shown. Which is a possible description of the current induced in the wire?

(1) none of the others  
(2)  
(3)  
(4)  
(5)  

14. A magnetic dipole is in a uniform magnetic field. The dipole experiences a torque of $20 \times 10^{-24}$Nm. The potential energy of the dipole is $15 \times 10^{-24}$J. What is the angle between the dipole and the magnetic field (in degrees)?

(1) 53  
(2) not enough information  
(3) 127  
(4) 37  
(5) 143  

15. In the figure, the current element $id\vec{l}$, the point P, and the three vectors (1, 2, 3) are all in the plane of the page. The direction of $d\vec{B}$, due to this current element, at the point P is:

(1) in the direction marked “3”  
(2) out of the page  
(3) in the direction marked “2”  
(4) in the direction marked “1”  
(5) into the page  

16. An electron and a proton both enter a region of uniform magnetic field with the same kinetic energy. They move perpendicular to the magnetic field. What is the ratio of the radius of the proton orbit to the radius of the electron orbit ($r_p/r_e$)?

(1) 43  
(2) 12.5  
(3) 5.4  
(4) 72  
(5) 9.8
17. A loop with a current is placed in a magnetic field as shown. What is the direction of torque $\vec{\tau}$ on the loop?

(1) $\vec{\tau}$ (2) $\vec{\tau}$ (3) $\vec{\tau}$ (4) $\vec{\tau}$ (5) the torque is zero

18. A circular loop of wire with radius 6.0cm and resistance 350mΩ is in the plane of the page. It is sitting in a magnetic field directed perpendicular to the page. The magnetic field strength varies in time and generates a counterclockwise current of 3.2A. Which of the following answers is a possibility for the direction and rate of change of the magnetic field?

(1) out of page, 99.0T/s (2) into page, 2.97T/s (3) none of the others (4) out of page, 2.97T/s (5) into page, 99.0T/s

19. Two parallel long wires carry the same current and repel each other with a force $F$ per unit length. If both these currents are doubled and the wire separation tripled, the force per unit length becomes:

(1) $2F/9$ (2) $4F/9$ (3) $6F$ (4) $4F/3$ (5) $2F/3$

20. Which graph correctly gives the magnitude of the magnetic field outside an infinitely long straight current-carrying wire as a function of the distance $r$ from the wire?

(1) $B$ (2) $B$ (3) $B$ (4) $B$ (5) $B$