Physics 227 – Hourly Exam 2  
Thursday, November 14, 2013, 9:40 PM - 11:00 PM  
ARC-103 (Aaa-Hez), Hill-114 (Hfa-Man),  
PLH (Mao-Rez), SEC-111 (Rfa-Tzz), SEC-118 (U-Z)

Your name sticker  
with exam code  
⇒ CIZEWSK1

SIGN HERE

1. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit RUID Number.
4. Under CODE enter the exam code given above.
5. Enter 227 under COURSE. You do not need to write anything else on the answer sheet for now, but you may continue to read the instructions.
6. During the exam, you are allowed one 8.5 x 11 inch sheet of paper with whatever you want written on it. NO Calculators. NO Cell phones.
7. The exam consists of 16 multiple-choice questions. For each multiple-choice question mark only one answer. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess.
8. If you have questions or problems during the exam, you may raise your hand and a proctor will assist you. If you need the value of a physical constant that is not given, we will provide it. It is your responsibility to know the relevant equations.
9. A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.
10. You are not allowed to help any other student, ask for help from anyone but a proctor, change your seat without permission from a proctor or use any electronic device. Doing so will result in a zero score for the exam.
11. When you are done with the exam, hand in only this cover sheet and your answer sheet.
12. Please sign above by the name sticker to indicate that you have read and understood these instructions.
Possibly useful constants:
k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2
\mu_0 = 4\pi \times 10^{-7} \text{ Wb/Am}
c = \text{speed of light} = 3.00 \times 10^8 \text{ m/s}
- q_{\text{electron}} = q_{\text{proton}} = 1.602 \times 10^{-19} \text{ C}
\text{m}_{\text{electron}} = \text{electron mass} = 9.11 \times 10^{-31} \text{ kg}
\text{m}_{\text{proton}} = \text{proton mass} = 1.67 \times 10^{-27} \text{ kg}
\text{Circumference of a circle} = 2\pi r; \text{ area of a circle is} \pi r^2
\text{Surface area of a sphere} = 4\pi r^2; \text{ volume of a sphere} = \frac{4}{3}\pi r^3
\text{Surface area of a cylinder} = 2\pi rh + 2\pi r^2; \text{ volume of cylinder} = \pi r^2h
\sin(0^\circ) = \cos(90^\circ) = 0
\sin(90^\circ) = \cos(0^\circ) = 1
\sin(30^\circ) = \cos(60^\circ) = \frac{1}{2}
\sin(60^\circ) = \cos(30^\circ) = \frac{\sqrt{3}}{2}
\sin(45^\circ) = \cos(45^\circ) = \frac{\sqrt{2}}{2}
\frac{dx^n}{dx} = nx^{n-1}
\int x^n = \frac{1}{n+1}x^{n+1} \text{ except when } n = -1. \text{ For } n = -1 \int \frac{dx}{x} = \ln x
\text{Some metric prefixes:}
f = \text{femto} = 10^{-15}
p = \text{pico} = 10^{-12}
n = \text{nano} = 10^{-9}
\mu = \text{micro} = 10^{-6}
m = \text{milli} = 10^{-3}
k = \text{kilo} = 10^3
M = \text{mega} = 10^6
G = \text{giga} = 10^9
1. In the figure is a loop of wire with sides $x = 1$ m and $y = 2$ m placed in a region where a uniform magnetic field $B = 1$ T exists and is directed out of the plane of the paper. The resistance of the loop is $R = 100$ Ω. If the magnetic field decreases from $B$ to zero during a time interval $\Delta t = 10$ s, what is the magnitude and direction of the induced current $I$ in the wire?

$$\mathcal{E} = \frac{d\Phi_B}{dt} = -\frac{(B_f - B_{in})(A)}{\Delta t}$$

a) $I = 2 \times 10^{-1}$ A, counterclockwise.

b) $I = 2 \times 10^{-3}$ A, counterclockwise.

c) $I = 2 \times 10^{-2}$ A, clockwise.

d) $I = 2 \times 10^{-2}$ A, counterclockwise.

e) $I = 2 \times 10^{-3}$ A, clockwise.

$$\mathcal{E} = \frac{(B_{in})(A)}{\Delta t} = \frac{10 L (I_1 \times I_2)}{10} = \frac{1}{5} V = I \times L = I = \frac{(10)(1/100)}{0.2 \times 10^{-2}} = 2 \times 10^{-3} \text{ CCW}$$

2. As shown in the figure, four very long, current-carrying wires in the same plane, are insulated from each other, and intersect to form a square with sides of length $L$. The currents running through the wires are 8.0 A, 20.0 A, 10.0 A and $I$. What are the magnitude and direction of the current $I$ that will make the magnetic field at the center of the square equal to zero?

a) There is no current that will make the magnetic field at the center equal to zero.

b) $I = 18.0$ A, down.

c) $I = 2.0$ A, up.

d) $I = 2.0$ A, down.

e) $I = 18.0$ A, up.

$$\frac{M_0 I_1}{2\pi r} + \frac{M_0 I_2}{2\pi r} + \frac{M_0 I_3}{2\pi r} + \frac{M_0 I_4}{2\pi r} = 0 \Rightarrow I_4 = 20 - 10 - 8 = 2 \text{ A}$$

and down (to give $B_4$ into the page)

3. A particle with charge $q = -1$ C is moving in the positive $+z$-direction at 5 m/s. The magnetic field at its position is $B = (4i + 3j)$ T. What is the magnetic force on the particle?

a) $\mathbf{F} = (-20i - 15j)$ N

b) $\mathbf{F} = (+15i + 20j)$ N

c) $\mathbf{F} = (+15i - 20j)$ N

d) $\mathbf{F} = (-15i + 20j)$ N

e) $\mathbf{F} = (+20i + 15j)$ N

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B})$$

$$F_x = qv_y B_z = -(1)(5)(3) = -15 \text{ N}$$

$$F_y = qv_x B_z = -(1)(5)(4) = -20 \text{ N}$$
4. You are given the following circuit where \( R_1 = R_2 = R_3 = R \) and the battery has voltage \( V = 120 \, V \). What is the power \( P \) dissipated in resistor \( R_1 \)?

a) \( P = \frac{2V^2}{3R} \)

b) \( P = \frac{4V^2}{9R^2} \)

c) \( P = \frac{4V^2}{9R} \)

d) \( P = \frac{4V^2R^2}{9} \)

e) \( P = \frac{V^2}{R} \)

\[ P = I^2 R = \left( \frac{4V}{9R^2} \right) R = \frac{4V^2}{9R} \]

5. Which of the following is a correct statement in words of the following Maxwell equation?

\[ \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 (I + e_0 \frac{d\Phi_B}{dt}) \]

a) Circulation of magnetic field around loop is proportional to the current + displacement current enclosed in loop.

b) Magnetic flux through loop is proportional to the current + displacement current enclosed in loop.

c) Circulation of electric field around loop is proportional to the rate of change of magnetic flux through loop.

d) Magnetic field lines never terminate due to the absence of magnetic monopoles.

e) The magnetic potential induced around a loop is proportional to the current enclosed by the loop.

6. Two positive point charges move side by side in the same direction with the same velocity \( v \). What is the direction of the magnetic force that one charge exerts on the other one?

a) None of the other answers is correct.

b) The magnetic force is towards the other point charge and attractive.

c) The magnetic force is away from the other point charge and repulsive.

d) The magnetic force is in the direction of the velocity \( v \).

e) The magnetic force is opposite to the direction of the velocity \( v \).

\[ \mathbf{F}_{\text{magnetic}} = \frac{q_1 q_2 \mathbf{r}}{4\pi \epsilon_0 r^2} \times \mathbf{v} \]

\[ \mathbf{F}_{\text{magnetic}} \text{ into the paper} \]

\[ \mathbf{F}_{\text{magnetic}} \text{ from } \mathbf{B} = \frac{q_1 q_2 \mathbf{r}}{4\pi \epsilon_0 r^2} \times \mathbf{v} \]

\[ \mathbf{F}_{\text{magnetic}} \text{ into the paper} \]
7. An EMF source with a voltage $V$, a resistor with a resistance $R$ and a capacitor with a capacitance $C$ are connected in series. Initially a switch in this circuit is open. At time $t = 0$ the switch is closed and the capacitor starts to charge. Which of the following statements about the current $I$ in the circuit and the charge $Q$ on the capacitor is TRUE? 

- $Q = CV(1 - e^{-t/RC})$
- $I = \frac{V}{R} (e^{-t/RC})$
- When $I = \frac{V}{4R}$, $Q = CV$.
- When $I = \frac{V}{2R}$, $Q = 2VC$.
- When $I = \frac{V}{4R}$, $Q = 3CV/4$.

\[ \text{When } I = \frac{V}{4R} \Rightarrow e^{-t/RC} = \left(\frac{V}{4R}\right)^{1/2} = \frac{1}{4} \]
\[ \Rightarrow Q = CV(1 - \frac{1}{4}) = \frac{3}{4} CV \]

8. You are given two metals. Metal A has $\rho_A = 20 \times 10^{-8}$ $\Omega$-m and Metal B has $\rho_B = 5 \times 10^{-8}$ $\Omega$-m. What diameter $d_B$ of a Metal B wire has the same resistance as a wire of the same length of Metal A with $d_A = 4$ mm?

- $d_B = 2$ mm
- $d_B = 4$ mm
- $d_B = 1$ mm
- $d_B = 0.5$ mm
- $d_B = 0.25$ mm

\[ R_A = \frac{\rho_A L}{\pi (d_A/2)^2} = \frac{\rho_B L}{\pi (d_B/2)^2} \]
\[ \Rightarrow \frac{(d_B)^2}{(d_A)^2} = \frac{\rho_B}{\rho_A} \Rightarrow d_B = \sqrt{\frac{5 \times 10^{-8} \text{ m}^{-1}}{2 \times 10^{-8} \text{ m}^{-1}}} \left(4 \text{ mm}^2\right) = \left(2 \text{ mm}\right) \sqrt{2} = 2.54 \text{ mm} \]

9. A bar magnet with its north end down is dropped through a circular loop of wire from far above. Magnetic field lines exit the magnet through its north end and enter the magnet through its south end. Seen from above, the direction of the current induced in the loop will

- first be counterclockwise and later clockwise.
- be one of the other options.
- always be counterclockwise.
- always be clockwise.
- first be clockwise and later counterclockwise.
10. A rectangular coil of wire of length \( L \), width \( W \) and area \( A = L \times W \) carries a current \( I \) in the counter-clockwise direction. It is originally oriented with the plane of its loop perpendicular to a uniform magnetic field \( B \) as shown in the figure. When the loop is ROTATED through an angle \( \theta \) about the axis shown, with the left side coming out of the plane of the figure and the right side going into the plane, which of the following statements is true about the net force \( F \) on the loop and the torque \( \tau \) on the loop?

\[ \sum F = 0 \quad \tau = \vec{I} \times \vec{B} = I A B \sin \theta \]

11. In this circuit, what is the \( EMF \) of the battery? Assume zero internal resistance for the battery.

- a) \( EMF = 4 \, \text{V} \)
- b) \( EMF = 12 \, \text{V} \)
- c) \( EMF = 8 \, \text{V} \)
- d) \( EMF = 20 \, \text{V} \)
- e) Impossible to determine without knowing the value of \( R \).

\[ \varepsilon = (4 \, \text{A})(2 \, \Omega) - (3 \, \text{A})(4 \, \Omega) = 20 \, \text{V} \]

12. When these measurements of current \( I \) in amperes and voltage \( V_{ab} \) in volts were made on a Thyrite resistor, which of the following statements is TRUE?

<table>
<thead>
<tr>
<th>( I )(A)</th>
<th>0.50</th>
<th>1.00</th>
<th>2.00</th>
<th>4.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{ab} )(V)</td>
<td>2.50</td>
<td>3.00</td>
<td>4.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>

- a) The material obeys Ohm’s law. **NO** \( R \) is constant \( R = \frac{\varepsilon}{I} = \frac{20 \, \text{V}}{3 \, \text{A}} = \frac{5}{3} \, \Omega \) when \( I = 3 \, \text{A} \).
- b) The resistance is \( R = 2.00 \, \Omega \) when \( I = 3.00 \, \text{A} \).
- c) The voltage is \( V_{ab} = 6.00 \, \text{V} \) when \( I = 3.00 \, \text{A} \).
- d) The power dissipated in the resistor \( P = 9.00 \, \text{W} \) when \( I = 1.00 \, \text{A} \).
- e) All of the options are false.
13. A solenoid has length $L$, diameter $D$ and $n$ turns per unit length with each carrying current $I$. $L$ is much greater than $D$. What is the magnetic field, $B_{out}$, outside of the solenoid and far away from the ends of the solenoid?

a) $B_{out} = +\mu_0 n I$

b) $B_{out} = +\mu_0 n I/2$

c) $B_{out} = -\mu_0 n I$

d) $B_{out} = -\mu_0 n I/2$

e) $B_{out}=0$

14. Consider the arrangement of ion source and electric field plates shown in the figure. The ion source sends particles with velocity $v$, charge $q$ and mass $m$ along the $+x$ axis. They encounter electric field plates spaced a distance $d$ apart that generate a uniform electric field of magnitude $E$ in the $+y$ direction. What is the magnitude of the magnetic field $B$ that will cause the charged particle to travel in a straight line under the combined action of electric and magnetic fields?

\[ \text{Uniform straight line} \Rightarrow B \times F = 0. \]

a) $B = E/v$

b) $B = Ev$

c) $B = mv/dq$

d) There is no non-zero value of the $B$ field that will cause the charged particle to travel in a straight line.

e) $B = v/E$

15. Which of the following statements is TRUE about electrical measuring instruments?

a) An ideal ammeter has zero resistance and should be connected in parallel with the circuit element being measured.

b) An ideal voltmeter has zero resistance and should be connected in parallel with the circuit element being measured.

c) An ideal ammeter has zero resistance and should be connected in series with the circuit element being measured.

d) An ideal voltmeter has infinite resistance and should be connected in series with the circuit element being measured.

e) An ideal ammeter has infinite resistance and should be connected in parallel with the circuit element being measured.
16. Two copper wires of different diameter are joined end-to-end, and a current flows in the wire combination. When electrons move from the larger-diameter wire into the smaller-diameter wire, which statement is TRUE?

$$I_A = n_e q A_A = I_B = n_e q A_B$$

$$\frac{V_B}{V_A} = \frac{A_A}{A_B} \Rightarrow V_B > V_A$$

$$\Rightarrow u_B \text{ increases}$$

a) Their drift speed decreases.
b) None of these options.
c) The drift speed stays the same.
d) The drift speed increases.
e) The current increases.