Physics 227 – Second Midterm Exam
Monday, April 8, 2019

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Physics 227,  Section
RUID:
Code: 000

Your name with exam code

Your signature ________________________________

Turn off and put away ALL electronic devices NOW. NO cell phones, NO smart watches, NO calculators, NO headphones.

1. The exam will last from 5:15 to 6:10 PM.
   Use a # 2 pencil to make entries in the circles at the bottom of the cover sheet.

2. Make sure your name and RU ID are correct on the cover page. CAREFULLY detach the cover sheet (with your name, ID and the answer circles).

3. During the exam, you may use pencils, NO calculator and ONE 8½" × 11" sheet of paper with handwritten (both sides) equations and notes.

4. There are 12 multiple-choice questions on the exam. For each question, mark ONE and only one answer on the answer sheet. There is no subtraction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess.

No marks except filled in answer circles below the line, please.

ABCDE

1: A B C D E

2: A B C D E

3: A B C D E

4: A B C D E

5: A B C D E

6: A B C D E

7: A B C D E

8: A B C D E

9: A B C D E

10: A B C D E

11: A B C D E

12: A B C D E
5. Before starting the exam, make sure that your copy contains all 12 questions and the information pages. Bring your exam to the proctor if this is not the case.

6. At the end of the exam, hand in only the cover sheet. Retain the question sheets for future reference and study.

7. If you have questions or problems during the exam, you may raise your hand and a proctor will assist you. We will provide the value of physical constants that are needed. It is your responsibility to know the relevant equations.

8. 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.

9. When you are done with the exam, sign the cover sheet, show your student ID to a proctor and hand in only the cover sheet.
Possibly useful constants:
\[ \varepsilon_0 = \frac{1}{\mu_0 c^2} = 8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2 \]
\[ k = \frac{1}{4\pi \varepsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2 \]
\[ c = \text{speed of light} = 3.00 \times 10^8 \text{ m/s} \]
\[ -q_{\text{electron}} = q_{\text{proton}} = 1.602 \times 10^{-19} \text{ C} \]
\[ m_{\text{electron}} = \text{electron mass} = 9.11 \times 10^{-31} \text{ kg} \]
\[ m_{\text{proton}} = \text{proton mass} = 1.67 \times 10^{-27} \text{ kg} \]
\[ \mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m/ } \text{A} = 12.57 \times 10^{-7} \text{ T} \cdot \text{m/ } \text{A} \]
\[ 1 \text{ eV} = 1.602 \times 10^{-19} \text{ J} . \]

Circumference of a circle =2\pi r; area of a circle is \( \pi r^2 \)
Surface area of a sphere =4\pi r^2; volume of a sphere = \( \frac{4}{3} \pi r^3 \)
Surface area of a cylinder =2\pi rh + 2\pi r^2; volume of cylinder = \( \pi r^2 h \)
\[ \sin(0^\circ) = \cos(90^\circ) = 0 \]
\[ \sin(90^\circ) = \cos(0^\circ) = 1 \]
\[ \sin(30^\circ) = \cos(60^\circ) = 1/2 \]
\[ \sin(60^\circ) = \cos(30^\circ) = \sqrt{3}/2 \]
\[ \sin(45^\circ) = \cos(45^\circ) = \sqrt{2}/2 \]
\[ \frac{d}{dx} x^n = nx^{n-1} \]
\[ \int x^n dx = \frac{1}{n+1} x^{n+1} \text{ except when } n = -1. \text{ For } n = -1, \int dx/x = \ln x \]
\[ \frac{d}{dx} \sin(ax) = a \cos(ax) \]
\[ \frac{d}{dx} \cos(ax) = -a \sin(ax) \]
\[ \int \sin(ax) dx = -\cos(ax)/a \]
\[ \int \cos(ax) dx = \sin(ax)/a \]

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. Consider two wires. Wire A is 10-cm long and wire B is 5-cm long. Both wires are otherwise identical and both have the same electric field acting in them. How does the current $I_A$ in wire A compare to the current $I_B$ in wire B?
   a) $I_A = 4I_B$
   b) $I_A = 2I_B$
   c) $I_A = I_B$
   d) $I_A = I_B/2$
   e) $I_A = I_B/4$

2. Two very long parallel wires are a distance $d$ apart and carry equal currents in opposite directions. At what point(s) is the net magnetic field due to those currents equal to zero?
   a) Midway between the wires.
   b) A distance $d/2$ to the left of the left wire and also a distance $d/2$ to the right of the right wire.
   c) A distance $d$ to the left of the left wire and also a distance $d$ to the right of the right wire.
   d) A distance $d/\sqrt{2}$ to the left of the left wire and also a distance $d/\sqrt{2}$ to the right of the right wire.
   e) There is no point (except infinity) at which the net field is exactly zero.

3. A cylindrical wire has a resistance $R_1$ and resistivity $\rho_1$. If its length and diameter are BOTH cut in half, what will be its resistivity $\rho_2$?
   a) $\rho_2 = 2\rho_1$
   b) $\rho_2 = \rho_1$
   c) $\rho_2 = (\rho_1)/2$
   d) $\rho_2 = 4\rho_1$
   e) $\rho_2 = (\rho_1)/4$
4. You are given a circuit with two batteries each with EMF=$\mathcal{E}$ and internal resistance $R_1$. They are connected in parallel to each other and then in series to a resistor with resistance $R_2$, as shown in the figure. What is the current $I$ flowing through the resistor $R_2$?

$$I = \frac{2\mathcal{E}}{2R_1 + R_2}$$

5. The figure shows, in cross section, several conductors that carry currents through the plane of the figure. The currents have the magnitudes $I_1=4$ A, $I_2=5$ A, and $I_3=2$ A, and the directions are shown. What is the magnitude of the line integral $\oint \vec{B} \cdot d\vec{l}$ around the path $d$ shown in the figure? Note $\mu_0 = 4\pi \times 10^{-7}$ T · m/A.

$$\oint \vec{B} \cdot d\vec{l} = 12\pi \times 10^{-7} \text{ T} \cdot \text{m}$$
6. In the figure a battery, resistor and capacitor are connected. The EMF of the battery is \( \varepsilon = 50 \text{ V} \), the capacitance is \( C = 5 \mu \text{F} \) and the resistance \( R = 100 \Omega \). When the voltage across the capacitor is \( V_C = 10 \text{ V} \), at what rate \( P \) is energy being stored in the capacitor?

a) \( P = 5 \text{ W} \)  
b) \( P = 1 \text{ W} \)  
c) \( P = 0.1 \text{ W} \)  
d) \( P = 4 \text{ W} \)  
e) \( P = 0.5 \text{ W} \)

7. Five equal mass particles (A to E) enter a region of uniform magnetic field directed into the page. While particle D is neutral, particles A, B, C, and E have the same magnitude of electric charge. They follow the trajectories illustrated in the figure. Rank the particles A, B, C, and E on the basis of their speed \( v \).

a) \( v_C = v_E > v_B > v_A \)  
b) \( v_A > v_C > v_E > v_B \)  
c) \( v_B > v_C = v_E > v_A \)  
d) \( v_A > v_B > v_C = v_E \)  
e) \( v_A > v_B > v_C > v_E \)
8. The Table summarizes measurements of current $I$ in amperes and voltage $V_{ab}$ in volts that 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.
b) The resistance is $R = 2.00 \ \Omega$ when $I=3.00 \ A$.
c) The voltage is $V_{ab} = 6.00 \ \text{V}$ when $I=3.00 \ A$.
d) The power dissipated in the resistor $P = 9.00 \ \text{W}$ when $I = 1.00 \ A$.
e) All of the options are false.

9. A very long, hollow, thin-walled conducting cylindrical shell (like a pipe) of radius $R$ carries a current along its length uniformly distributed throughout the thin shell. Which one of the graphs in the figure most accurately describes the magnitude $B$ of the magnetic field produced by this current as a function of the distance $r$ from the central axis? (Can assume that the shell is very, very thin.)

![Graphs](image-url)
10. A current $I = 1$ A flows around a plane circular loop of radius $r = 1$ cm, giving the loop a magnetic moment of magnitude $m$. The loop is placed in a uniform magnetic field $\vec{B} = 2$ T with an angle $\phi = 30$ degrees between the direction of the field lines and the magnetic dipole moment, as shown in the figure. What is the magnitude of the torque $\tau$ on the current loop?

a) $\tau = 2\pi \times 10^{-2}$ N-m  
b) $\tau = \pi \times 10^{-4}$ N-m  
c) $\tau = 2\pi \times 10^{-4}$ N-m  
d) $\tau = \pi \times 10^{-2}$ N-m  
e) $\tau = \sqrt{3}\pi \times 10^{-4}$ N-m

11. A light bulb is connected in the circuit shown in the figure with the switch $S$ open. All of the connecting leads and the ideal battery have no resistance. After the switch is closed, which statement accurately describes the behavior of the circuit?

a) The potential drop across $R_2$ will not change.  
b) The brightness of the light bulb will decrease.  
c) The brightness of the light bulb will increase.  
d) The brightness of the light bulb will not change.  
e) The potential drop across $R_2$ will increase.
12. 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 charge to travel in a straight line under the combined action of electric and magnetic fields?

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) \( B = v/E \)