Physics 202 Midterm Exam 3  
November 22, 2010

Name: ..................................................  Student ID:  .........................
Section:  ..............................................

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Instructions:

1. Don't forget to write down your name, student ID#, and section number. You need to do this on (this page of) your test book and on your Scantron sheet as well.

2. Answer all multiple choice questions in this test book by indicating the best answer among choices. You must do this both on your test book and on your Scantron sheet. Follow instructions on the Scantron sheet on how to mark valid answers.

3. When you finish, you need to turn in both this test book and the Scantron sheet.

4. Use the blank side of question pages as additional draft spaces. An extra blank sheet is provided at the end of the test book.

5. Only one answer is allowed per problem/question. All problems have equal weight.

Constants:
\[ \varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{Nm}^2), \quad \mu_0 = 4\pi \times 10^{-7} \text{ T m/A}, \quad c = 3.0 \times 10^8 \text{ m/s} \]

Please be very careful with the first question even though the answer will not count towards your grade:

1. ENTER THE ID CODE ABOVE IN THE UPPER RIGHT CORNER  
A. ID Code A  
B. ID Code B  
C. ID Code C  
D. ID Code D  
E. ID Code E
2. At a point in space where the magnetic field is measured, the magnetic field produced by an electric current element
A. points radially away in the direction from the current element to the point in space.
B. points radially in the direction from the point in space towards the current element.
C. points in a direction parallel to the current element.
D. points in a direction parallel to but opposite in direction to the current element.
E. points in a direction that is perpendicular to the current element and perpendicular to the radial direction.

3. Three long wires parallel to the x axis carry currents as shown. If \( I = 20 \, \text{A} \), what is the magnitude of the magnetic field at the origin?
A. 37 \( \mu \text{T} \)
B. 28 \( \mu \text{T} \)
C. 19 \( \mu \text{T} \)
D. 47 \( \mu \text{T} \)
E. 58 \( \mu \text{T} \)

\[
\mathbf{B}_0 = \frac{\mu_0}{2\pi} \left( \frac{4I}{2m} + \frac{3I}{1m} + \frac{I}{3m} \right)
\]
\[
\mathbf{B}_0 = \frac{\mu_0}{2\pi} \left( \frac{\frac{14}{3}I}{3} \right)
\]
\[
\mathbf{B}_0 = \frac{2 \times 10^{-7} \times 14 \times 20}{3} = 18,6 \times 10^{-6} \frac{T}{3}
\]

4. Two long parallel wires are separated by 6.0 mm. The current in one of the wires is twice the other current. If the magnitude of the force on a 3.0-m length of one of the wires is equal to 8.0 \( \mu \text{N} \), what is the greater of the two currents?
A. 0.20 A
B. 0.40 A
C. 40 mA
D. 20 mA
E. 0.63 A

\[
F = \frac{\mu_0}{2\pi} \frac{I_1 I_2}{r} \quad \text{where} \quad r = 0.006 \, \text{m}
\]
\[
F = \frac{2 \times 10^{-7} \times 8 \times 10^{-6}}{3} \cdot \frac{6 \times 10^{-3}}{18^2} = 6.7 \times 10^{-10} \, \text{N}
\]

5. A long solenoid (diameter = 5.0 cm) is wound with 960 turns per meter of thin wire through which a current of 300 mA is maintained. A wire carrying 12 A is inserted along the axis of the solenoid. What is the magnitude of the magnetic field at a point 2.0 cm from the axis?
A. 0.41 mT
B. 0.48 mT
C. 0.38 mT
D. 0.56 mT
E. 0.24 mT

\[
\mathbf{B}_s = \eta \mu_0 I = 960 \times 4\pi \times 10^{-7} \times 0.3 = 0.36 \, \text{mT}
\]
\[
\mathbf{B}_{wire} = \frac{\mu_0 I}{2\pi a} = 2 \times 12 \times 10^{-7} \times \frac{1}{0.02} = 0.12 \, \text{mT}
\]
\[
\mathbf{B}_{2.0cm} = \sqrt{\mathbf{B}_s^2 + \mathbf{B}_{wire}^2} = 0.379 \, \text{mT}
\]
6. The magnetic flux through a loop perpendicular to a uniform magnetic field will change
A. if the loop is replaced by two loops, each of which has half of the area of the original loop.
B. if the loop moves at constant velocity while remaining perpendicular to and within the uniform magnetic field.
C. if the loop moves at constant velocity in a direction parallel to the axis of the loop while remaining in the uniform magnetic field.
D. if the loop is rotated through 180 degrees about an axis through its center and in the plane of the loop.
E. in none of the above cases.

7. A bar magnet is dropped from above and falls through the loop of wire shown below. The north pole of the bar magnet points downward towards the page as it falls. Which statement is correct?

A. The current in the loop always flows in a clockwise direction.
B. The current in the loop always flows in a counterclockwise direction.
C. The current in the loop flows first in a clockwise, then in a counterclockwise direction.
D. The current in the loop flows first in a counterclockwise, then in a clockwise direction.
E. No current flows in the loop because both ends of the magnet move through the loop.

8. A flat coil of wire consisting of 20 turns, each with an area of 50 cm², is positioned perpendicularly to a uniform magnetic field that increases its magnitude at a constant rate from 2.0 T to 6.0 T in 2.0 s. If the coil has a total resistance of 0.40 Ω, what is the magnitude of the induced current?
A. 0.70 A
B. 0.60 A
C. 0.50 A
D. 0.80 A
E. 0.20 A
9. A conducting bar moves as shown near a long wire carrying a constant 80-A current.
If \( a = 1.0 \) mm, \( b = 20 \) mm, and \( v = 5.0 \) m/s, what is the potential difference, \( V_a - V_b \)?

A. \(-0.24\) mV  
B. \(+0.24\) mV  
C. \(-0.19\) mV  
D. \(+0.19\) mV  
E. \(-0.76\) mV

10. A series LC circuit contains a 100 mH inductor, a 36.0 mF capacitor and a 12 V battery.
The frequency of the electromagnetic oscillations in the circuit is
A. \(5.73 \times 10^{-4}\) Hz.  
B. \(9.55 \times 10^{-3}\) Hz.  
C. \(0.442\) Hz.  
D. \(2.65\) Hz.  
E. \(44.0\) Hz.

11. What is the inductance of a series RL circuit in which \( R = 1.0\) K\(\Omega \) if the current increases to one-third of its final value in \(30\ \mu s\)?

A. 74 mH  
B. 99 mH  
C. 49 mH  
D. 62 mH  
E. none of the above

12. Whenever the alternating current frequency in a series RLC circuit is halved,
A. the inductive reactance is doubled and the capacitive reactance is halved.  
B. the inductive reactance is doubled and the capacitive reactance is doubled.  
C. the inductive reactance is halved and the capacitive reactance is halved.  
D. the inductive reactance is halved and the capacitive reactance is doubled.  
E. the reactance of the circuit remains the same.

\[ X_L = \omega L, \quad X_c = \frac{1}{\omega C} \]

\( \omega \rightarrow \frac{1}{2} \omega \), \( X_L \) halved, \( X_c \) doubled.
13. A series $RLC$ circuit has an impedance of $120 \Omega$ and a resistance of $64 \Omega$. What average power is delivered to this circuit when $V_{\text{rms}} = 90$ volts?

A. 36 W
B. 100 W
C. 192 W
D. 360 W
E. 12 W

\[ P_{\text{ave}} = \Delta V_{\text{rms}}^2 \cdot \frac{R}{2} = 90^2 \cdot \frac{64}{120^2} = 36 \text{ W} \]

14. Determine the rms voltage for the circuit.

A. 99 V (rms)
B. 140 V (rms)
C. 196 V (rms)
D. 70 V (rms)
E. 110 V (rms)

\[ \Delta V_{\text{rms}} = \frac{1}{\sqrt{2}} \Delta V_{\text{max}} = \frac{140}{\sqrt{2}} = 99 \text{ V} \]

15. Determine the resonant frequency of the circuit.

A. 159 Hz
B. 32 Hz
C. 5 Hz
D. 500 Hz
E. 79.5 Hz

\[ f_0 = \frac{\omega_0}{2\pi} = \frac{1000}{2\pi} \]

16. The voltage $8.00 \sin(400t)$ is applied to a series $RLC$ circuit, with $R = 200 \Omega$, $L = 0.100$ H, and $C = 1.00 \mu$F. What are the impedance $Z$ and the phase angle $\phi$?

A. 200 $\Omega$, $-37.0^\circ$
B. 566 $\Omega$, $+87.0^\circ$
C. 2470 $\Omega$, $-85.4^\circ$
D. 2540 $\Omega$, $-88.8^\circ$
E. 393 $\Omega$, $-63.0^\circ$

\[ Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{200^2 + (400 - \frac{1}{4 \times 10^6})^2} = 2468 \Omega \]

\[ \phi = \tan^{-1} \frac{X_L - X_C}{R} = \tan^{-1} \frac{-2460}{200} = -85.35^\circ \]
17. At every instant the ratio of the magnitude of the electric to the magnetic field in an electromagnetic wave in vacuum is equal to
A. the speed of radio waves.
B. the speed of light.
C. the speed of gamma rays.
D. all of the above.
E. only A and B above.

18. The magnetic field of a plane-polarized electromagnetic wave moving in the z-direction is given by \( B = 1.2 \times 10^{-6} \sin \left[ 2\pi \left( \frac{z}{240} - \frac{t \times 10^7}{8} \right) \right] \) in SI units. What is the frequency of the wave?
A. 500 MHz
B. 250 kHz
C. 1.25 MHz
D. 10 mHz
E. 300 MHz

\[ f = \frac{v}{\lambda} = \frac{1.0 \times 10^8}{1.25 \times 10^6} = 80 \text{ Hz} \]

19. What should be the height of a dipole antenna (of dimensions 1/4 wavelength) if it is to transmit 1 200 kHz radio waves?
A. 11.4 m
B. 60 cm
C. 1.12 m
D. 62.5 m
E. 250 m

\[ h = \frac{\lambda}{4} = \frac{1}{4} \left( \frac{C}{f} \right) = \frac{1}{4} \left( \frac{3 \times 10^8}{1200 \times 10^3} \right) = 6.25 \text{ m} \]

20. At a distance of 10 km from a radio transmitter, the amplitude of the E-field is 0.20 volts/meter. What is the total power emitted by the radio transmitter?
A. 10 kW
B. 67 kW
C. 140 kW
D. 245 kW
E. 21 kW

\[ P_{\text{tot}} = 4\pi R^2 \int_{d_{\text{min}}}^{d_{\text{max}}} E^2 \, dt = 4\pi (10^3)^2 \left( \frac{0.20 \times 10^{-3}}{2} \right)^2 = 66.7 \times 10^2 \text{ W} \]

21. What is the maximum radiation pressure exerted by sunlight in space \((S = 1350 \text{ W/m}^2)\) on a highly polished silver surface?
A. \(1.4 \times 10^{-2} \text{ Pa} \)
B. \(0.12 \text{ Pa} \)
C. \(9.0 \times 10^{-6} \text{ Pa} \)
D. \(4.5 \times 10^{-5} \text{ Pa} \)
E. \(2.3 \times 10^{-6} \text{ Pa} \)

\[ P_{\text{pres}} = \frac{2S}{c} = \frac{2 \times 1350}{3 \times 10^8} = 9 \times 10^{-6} \text{ Pa} \]