Physics 202
Exam 3
April 21, 2010

Please fill out following information on scantron sheet:

Last Name, First Name, Middle Initial
ID #
Put Section # as Special Code

Some useful constants:
- Coulomb constant $k = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$
- Electric constant $\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$
- Magnetic constant $\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m/A}$
- Electron charge $e = -1.6 \times 10^{-19} \text{ C}$
- Speed of light in vacuum $c = 2.998 \times 10^8 \text{ m/s}$

Voltage across inductor = $L \frac{dI}{dt}$ (L = inductance)
Voltage across capacitor = $\frac{Q}{C}$ (C = capacitance)

Wave speed on a string with mass/length $= \mu$ and tension $T$: $v = \sqrt{\frac{T}{\mu}}$

Average energy in length $\Delta x$ of a wave on a string = $(1/2) \mu \omega^2 A^2 \Delta x$ ($\mu$ = mass/length, $A$ = amplitude, $\omega$ = angular frequency, $\mu$ = mass/length)

EXAM KEY

1. C
2. E
3. A
4. C
5. B
PROBLEMS

6. A coil of self inductance 7.5 mH and resistance of 30 $\Omega$ is placed across the terminals of a 12-V battery of negligible internal resistance. The current in this circuit 50 $\mu$s after the inductor and resistor are placed across the battery is approximately

A) 73 mA
B) 47 mA
C) 28 mA
D) 51 mA
E) 19 mA

7. In this circuit, $\varepsilon_0 = 12$ V, $R = 6.0$ $\Omega$, and $L = 0.48$ H. The switch is closed at time $t = 0$. At time $t = 0.25$ s, the power dissipated in the resistor is approximately

\[\varepsilon \quad R \quad L \quad \frac{di}{dt}\]

A) 17 W
B) 22 W
C) 51 W
D) 37 W
E) 11 W

8. A cylindrical solenoid is 15 cm long, has a radius of 5 cm, and has 400 turns. If it carries a current of 4 A, the magnetic energy stored in the solenoid is

A) 84.2 mJ
B) 0.562 J
C) 3.37 J
D) 12.6 mJ
E) None of these is correct.
9. An uncharged capacitor and a resistor are connected in series to a battery as shown. If \( \varepsilon = 15 \text{ V} \), \( C = 20 \mu\text{F} \), and \( R = 4.0 \cdot 10^5 \Omega \), the charge on the capacitor as a function of time is

A) \( Q(t) = 600 \left( 1 - e^{-0.125t} \right) \mu\text{C} \)

B) \( Q(t) = 300 \left( 1 - e^{-0.250t} \right) \mu\text{C} \)

C) \( Q(t) = 300 \left( 1 - e^{-0.125t} \right) \mu\text{C} \)

D) \( Q(t) = 600 \left( 1 - e^{-0.250t} \right) \mu\text{C} \)

E) \( Q(t) = 150 \left( 1 - e^{-0.750t} \right) \mu\text{C} \)

10. A 20.0-\( \mu\text{F} \) capacitor is charged to 200 V and is then connected across a 1000-\( \Omega \) resistor. What is the initial current just after the capacitor is connected to the resistor?

A) 100 mA

B) **200 mA**

C) 150 mA

D) 300 mA

E) 50 mA

11. A flat, rectangular coil measuring 0.10 m by 0.20 m and containing 50 turns of wire is rotating with a constant angular speed of 100\( \pi \) rad/s in a magnetic field of 0.20 T. The maximum EMF induced in this coil is approximately

A) 1.0 V

B) 10 V

C) **63 V**

D) 44 V

E) 0.13 V

12. A series \( RLC \) circuit is driven by a 1.0-kHz oscillator. The circuit parameters are \( L = \)
5.0 mH, \( C = 4.0 \mu F \), \( R = 10 \Omega \). What is the impedance of this circuit?

A) 8.4 \( \Omega \)
B) 10 \( \Omega \)
C) 13 \( \Omega \)
D) 0.24 k\( \Omega \)
E) 81 \( \Omega \)

13. You connect a 250-\( \Omega \) resistor, a 1.20-mH inductor, and a 1.80-\( \mu F \) capacitor in series across a 60.0-Hz, 120-V (peak) source. The rms voltage across the capacitor in this circuit is approximately

A) 25.7 mV
B) 83.7 V
C) 120 V
D) 14.2 V
E) 84.9 V

14. A 5-\( \mu F \) capacitor is charged to 30 V and is then connected in series with a 10-\( \mu H \) inductor. The resulting current in the circuit oscillates with a frequency of

A) \( 4.4 \times 10^5 \) Hz
B) \( 8.9 \times 10^5 \) Hz
C) \( 2.0 \times 10^{10} \) Hz
D) \( 2.3 \times 10^4 \) Hz
E) \( 1.4 \times 10^5 \) Hz

15. A parallel-plate capacitor has closely spaced circular plates of radius \( R = 2.50 \) cm. Charge is flowing onto the positive plate at the rate \( I = \frac{dQ}{dt} = 4.3 \) A. The magnetic field at a distance \( r = 1.50 \) cm from the axis of the plates is approximately

A) 2.06 \( \mu T \)
B) 206 \( \mu T \)
C) 20.6 \( \mu T \)
D) 13.5 \( \mu T \)
E) 135 \( \mu T \)

16. An electromagnetic wave is propagating in the \(+\hat{i}\) direction and its electric field is
given by $\vec{E} = E_0 \sin(kx - \omega t) \hat{j}$. The corresponding magnetic field wave is (where $B_0 = E_0/c$)

A) $\vec{B} = B_0 \sin(kx - \omega t) \hat{i}$.

B) $\vec{B} = B_0 \sin(kx - \omega t) \hat{k}$.

C) $\vec{B} = B_0 \cos(kx - \omega t) \hat{j}$.

D) $\vec{B} = -B_0 \sin(kx - \omega t) \hat{k}$.

E) $\vec{B} = -B_0 \cos(kx - \omega t) \hat{j}$.

17. Which of the following statements is false?

A) Both the $\vec{B}$ and the $\vec{E}$ components of an electromagnetic wave satisfy the wave equation.

B) The phase of a wave traveling in the negative $z$ direction is $kz + \omega t$.

C) The speed of an electromagnetic wave traveling in a vacuum is given by $(\varepsilon_0 \mu_0)^{-1/2}$.

D) The magnitude of $\vec{E}$ is greater than the magnitude of $\vec{B}$ by a factor of $c^2$.

E) In an electromagnetic wave, $\vec{E}$ and $\vec{B}$ are perpendicular to each other.

18. The rms value of the magnitude of the magnetic field in an electromagnetic wave is $B_{rms} = 0.378$ T. The time average of the total energy density of this wave is approximately

A) $114$ kJ/m$^3$

B) $28.4$ kJ/m$^3$

C) $31.8$ kJ/m$^3$

D) $67.8$ kJ/m$^3$

E) $56.9$ kJ/m$^3$

19. The graph shows a plot of the function $	ext{Y}$.
Y = \cos(kX). The value of k is
A) 1/2
B) 1/4
C) $\pi/2$
D) $\pi$
E) 2$\pi$

20. A 60-W light bulb emits spherical electromagnetic waves uniformly in all directions. If 50% of the power input to such a light bulb is emitted as electromagnetic radiation, what is the maximum value of the electric field at a distance of 2.0 m from the light bulb?
A) 43 V/m
B) 0.11 mV/m
C) 21 V/m
D) 60 V/m
E) 30 V/m

21. A string of mass $2.4 \times 10^{-3}$ kg and length 0.60 m vibrates transversely in such a way that its fundamental frequency is 100 Hz. The tension on this string must be approximately
A) 0.16 N
B) 0.32 N
C) 13 N
D) 26 N
E) 58 N

22. The Sun radiates about $3.83 \times 10^{26}$ W of power. How large should a perfectly reflecting solar sail be on a space ship of mass 50 kg to provide an acceleration of $10^{-4}$ m/s$^2$ at a distance from the sun of $1.50 \times 10^{11}$ m?
A) 550 m$^2$
B) 625 m$^2$
C) 1100 m$^2$
D) 2500 m$^2$
E) None of these is correct

23. A sinusoidal wave train is moving along a string. The equation giving the
displacement as a function of position and time is
\[ y(x, t) = 0.12 \sin(8\pi(t - x/50)), \]
where the units are SI. For a particle at \( x = 5 \) m when \( t = 2.4 \) s, the velocity of the particle is
A) 3.7 cm/s
B) 27 cm/s
C) 93 cm/s
D) 1.6 m/s
E) 3.0 m/s

25. Harmonic waves of amplitude 1.3 cm move along a 14-m long string that has a mass of 90 g and is under a tension of 18 N. If the average total energy of the waves in the string is 5 J, calculate the frequency of the waves.
A) 21 Hz
B) 811 Hz
C) 129 Hz
D) 92 Hz
E) 256 Hz