Key

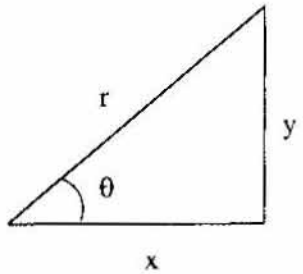
Physics 241 – Exam #2

March 31 **2005**

This exam consists of 13 problems on 9 pages. **Please check that you have them all.** Each problem is worth 8 points unless otherwise noted.

All of the formulas that you will need are given below. You may also use a calculator.

$\sin\theta = y/r$ $\cos\theta = x/r$ $\tan\theta = y/x$



$e = 1.6 \times 10^{-19}$ C $k = 9.0 \times 10^9\ \mathrm{N\cdot m^2/C^2}$ $\epsilon_0 = 8.9 \times 10^{-12}\ \mathrm{C^2/(N\cdot m^2)}$

$$F = \frac{kq_1q_2}{r^2} = \frac{q_1q_2}{4\pi\epsilon_0 r^2} \qquad E = \frac{kq}{r^2} \qquad \Phi = \int \vec{E}\cdot d\vec{A} = \frac{q}{\epsilon_0} \qquad \text{charged plane}: E = \frac{\sigma}{2\epsilon_0}$$

$$\Delta V = \frac{\Delta U_E}{q} = -\int \vec{E}\cdot d\vec{l} \qquad dV = -\vec{E}\cdot d\vec{l} \qquad \text{point charge}: V = \frac{kq}{r} \qquad U_E = q_0V = \frac{kqq_0}{r}$$

$$E_x = -\frac{\partial V}{\partial x} \qquad 1\text{ Volt} = 1\text{ J / C} \qquad 1\text{ Volt/m} = 1\text{ N / C} \qquad U_E = \frac{1}{2}qV \qquad C = \frac{q}{V}$$

$$\text{Surface area(sphere)} = 4\pi R^2 \qquad \text{capacitor}: U_E = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}qV = \frac{1}{2}CV^2 \qquad u_E = \frac{1}{2}\epsilon_0E^2$$

$$\text{parallel plate capacitor}: C = \frac{\epsilon_0 A}{d} \qquad \text{isolated spherical capacitor}: C = 4\pi\epsilon_0 R$$

$$\text{capacitors in parallel}: C = C_1 + C_2 + C_3 ... \qquad \text{capacitors in series}: \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}...$$

$$C = \kappa C_0 \qquad I = \frac{\Delta q}{\Delta t} \qquad R = \frac{V}{I} \qquad R = \rho\frac{L}{A} \qquad V = IR$$

$$P = IV = I^2R = \frac{V^2}{R} \qquad P = \mathcal{E}I \qquad \text{resistors in series}: R = R_1 + R_2 + R_3 ...$$

$$\text{resistors in parallel}: \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} ... \qquad q(t) = q_0 e^{-t/(RC)} = q_0 e^{-t/\tau}$$

$$I(t) = \frac{V}{R} e^{-t/(RC)} = I_0 e^{-t/\tau} \qquad \tau = RC$$

$$q(t) = C\mathcal{E}(1 - e^{-t/(RC)}) = q_0(1 - e^{-t/\tau}) \qquad I(t) = \frac{\mathcal{E}}{R} e^{-t/(RC)} = I_0 e^{-t/\tau}$$

$$\vec{F_B} = q\vec{v} \times \vec{B} \qquad \vec{F_B} = I\vec{L} \times \vec{B} \qquad \vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$$

$$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A} \quad d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{\ell} \times \hat{r}}{r^2} \quad \int \vec{B} \cdot d\vec{\ell} = \mu_0 I \quad B(\text{center of circular loop}) = \frac{\mu_0 I}{2R}$$

$$B(\text{wire}) = \mu_0 I/(2\pi r) \qquad B(\text{solenoid}) = \mu_0 n I \qquad \mathcal{E} = -\frac{d\Phi_B}{dt} \qquad U_L = \frac{1}{2} L I^2$$

$$V_L = -L\frac{dI}{dt} \qquad L = \mu_0 n^2 A \ell \qquad U_B = \frac{1}{2\mu_0} B^2 (Vol) \qquad u_B = \frac{1}{2\mu_0} B^2$$

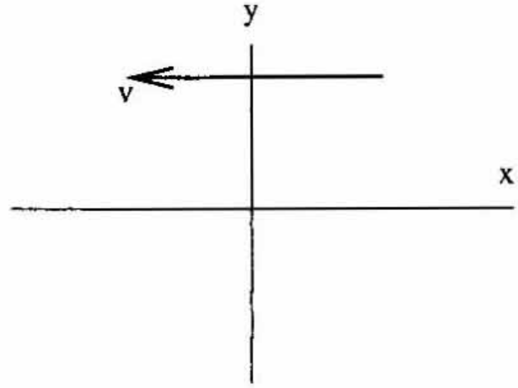
$$I = \frac{V}{R}(1 - e^{(-t/\tau)}) \qquad |V_L| = V e^{(-t/\tau)} \qquad \tau = L/R$$

$$\omega = 2\pi f \qquad X_C = \frac{1}{\omega C} \qquad X_L = \omega L \qquad \omega_{resonance} = \frac{1}{\sqrt{LC}}$$

$$I_{rms} = \frac{1}{\sqrt{2}} I_{peak} \qquad I_{rms} = \frac{V_{rms}}{R} \qquad I_{rms} = \frac{V_{rms}}{X_C} \qquad I_{rms} = \frac{V_{rms}}{X_L} \qquad P_{ave} = I_{rms}^2 R$$

$$I_{peak} = \frac{V_{peak}}{R} \qquad I_{peak} = \frac{V_{peak}}{X_C} \qquad I_{peak} = \frac{V_{peak}}{X_L}$$

1. An electron is moving in the $x-y$ plane with the velocity vector indicated in the figure below. If the magnetic force on the electron is in the $+z$ direction, what is the direction of the magnetic field?



(a) $\vec{B}$ is along the $-z$ direction

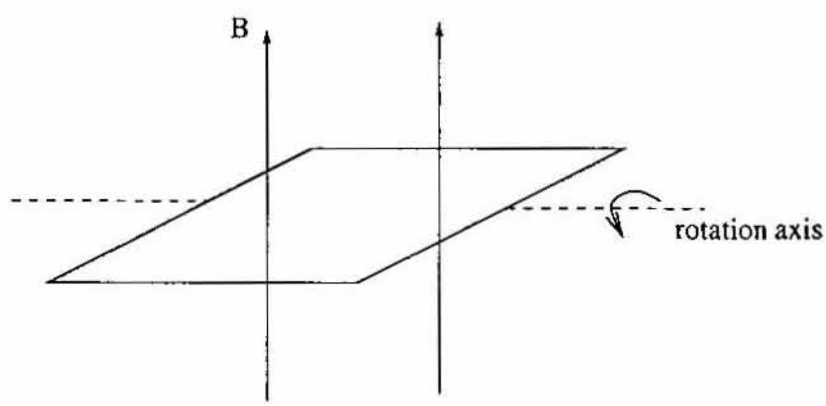
(b) $\vec{B}$ is along the $+x$ direction

(c) $\vec{B}$ is along the $-x$ direction

(d) $\vec{B}$ is along the $+y$ direction

(e) $\vec{B}$ is along the $-y$ direction

2. The Earth's magnetic field is approximately 5×10^{-5} T. Suppose that a square coil of edge length 0.10 m is rotated with a frequency of $f = 400$ Hz about an axis that is perpendicular to the Earth's field. The induced emf in this coil will vary with time according to $\mathcal{E} = V_0 sin(2\pi f t)$. What is V_0?



(a) 0.13 V

(b) 3.1×10^{-7} V

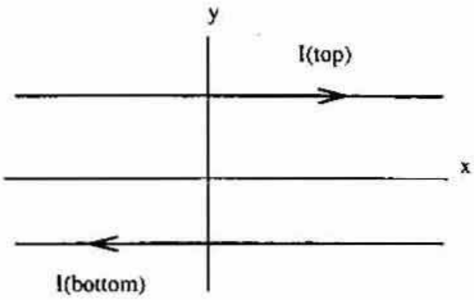
(c) 2.1×10^{-4} V

(d) 1.3×10^{-3} V

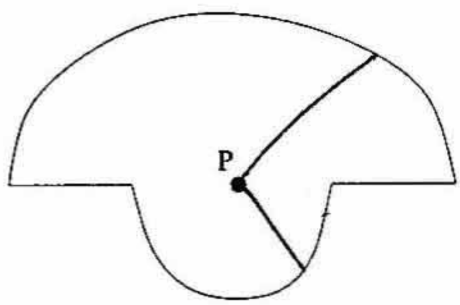
(e) 6.2×10^{-3} V

3. Two long wires lie parallel to the x axis and are separated by a distance 0.15 m as shown below. If the top wire carries a current of 2.5 A directed to the right, and the bottom wire carries a current of 4.5 A directed to the left, what is the magnetic force on a 1.5 m section of the bottom wire?

(a) 1.2×10^{-6} N directed upwards
(b) 2.3×10^{-5} N directed downwards
(c) 3.3×10^{-5} N directed downwards
(d) 3.3×10^{-5} N directed upwards
(e) 1.5×10^{-5} N directed downwards

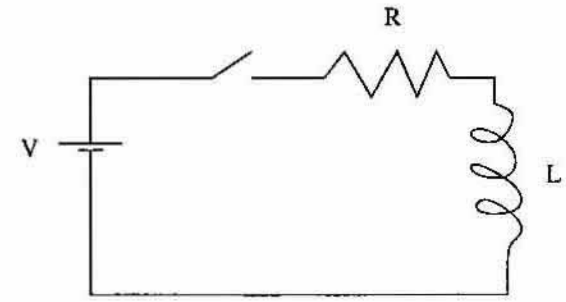


4. A loop of wire is bent as shown – the upper portion is a semicircle of radius 0.50 m, the bottom part is a semicircle of radius 0.20 m, and they are connected by straight sections. If the current flowing in the wire is 2.5 A, find the magnitude of the magnetic field at the center (at point P).



(a) 3.1×10^{-7} T
(b) 4.0×10^{-6} T
(c) 1.6×10^{-6} T
(d) 7.9×10^{-7} T
(e) 5.5×10^{-6} T

5. This switch is open for a very long time, and then closed at $t = 0$. What is the voltage across the resistor just after the switch is closed?



(a) infinite

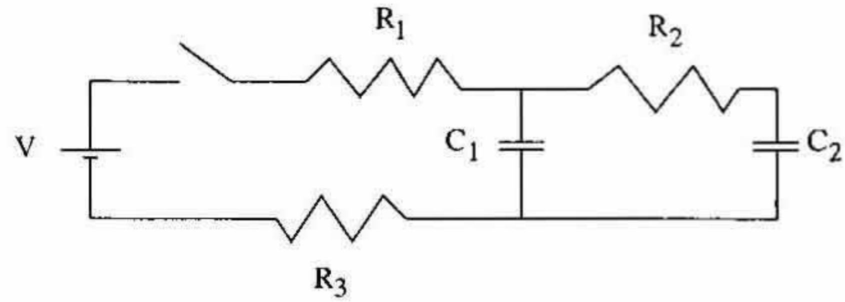
(b) zero

(c) $-V$

(d) V

(e) V/R

6. The switch in this $R - C$ circuit is initially open and the capacitors are uncharged. What is the current through R_1 immediately after the switch is closed? Assume that $R_1 = 2000\ \Omega$, $R_2 = 3000\ \Omega$, $R_3 = 1500\ \Omega$, $C_1 = 1.5$ F, and $C_2 = 2.5$ F, and that the battery has an emf $V = 3.0$ V.



(a) zero

(b) 0.46 mA

(c) 2.0 mA

(d) 0.86 mA

(e) 1.5 mA

7. A proton is at the origin and is moving in the $+z$ direction. What is the direction of the magnetic field due to the proton at a location on the x axis at $x = 1$ m?

(a) parallel to the vector $\hat{x} + \hat{y}$

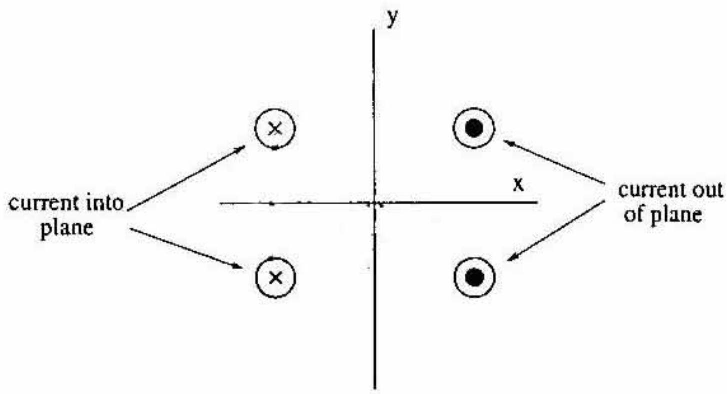
(b) $-x$

(c) $+x$

(d) $-y$

(e) $+y$

8. Four very long wires are directed perpendicular to the plane of the drawing below. The points where these wires cross the plane of the drawing form a square of edge length 0.45 m, and each wire carries a current of magnitude 2.5 A. Find the magnetic field at the center of the square (i.e., at the origin).



(a) $B_x = 0$, $B_y = -2.2 \times 10^{-6}$ T

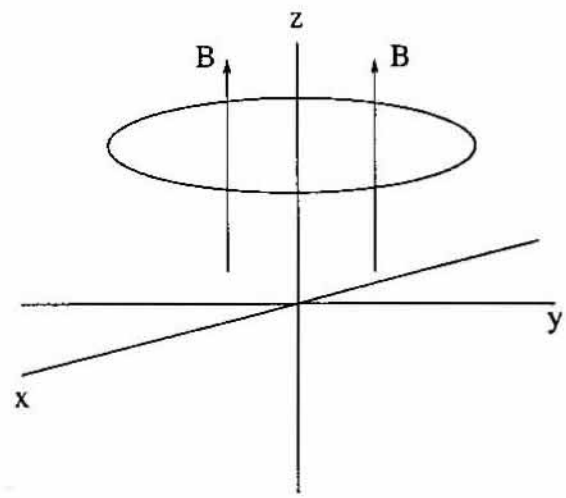
(b) $B_x = 0$, $B_y = -4.4 \times 10^{-6}$ T

(c) $B_x = 0$, $B_y = -6.2 \times 10^{-6}$ T

(d) $B_x = 0$, $B_y = +6.2 \times 10^{-6}$ T

(e) $B_x = 0$, $B_y = -1.1 \times 10^{-6}$ T

9. A circular loop of wire lies in the $x-y$ plane, so that the axis of the loop lies along z. A magnetic field of magnitude B is parallel to the z axis – this field is positive (i.e., along the $+z$ direction), and is the same everywhere within the area of the loop. If B is decreasing with time, what is the direction of the induced current in the loop?



(a) counterclockwise as viewed from above
(b) clockwise as viewed from above
(c) zero - there is no induced current

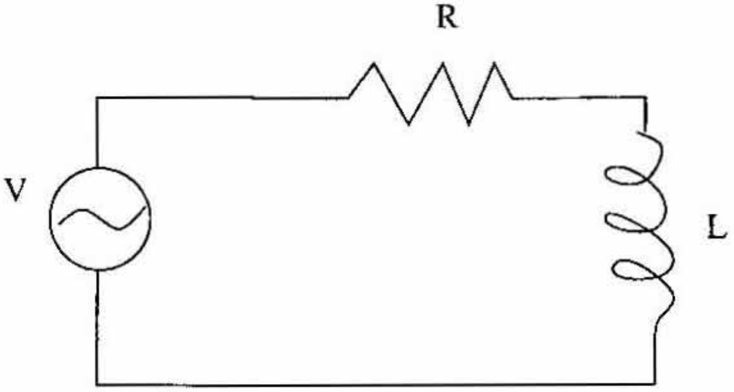
10. At what frequency is the reactance of a 1.5 μF capacitor equal to the reactance of a 0.55 mH inductor?

(a) 3.5×10^4 Hz
(b) 2.8×10^{-5} Hz
(c) 1.7×10^4 Hz
(d) 1.5×10^3 Hz
(e) 5.5×10^3 Hz

11. Consider the AC circuit shown below. The AC voltage has an amplitude of $V_0 = 1.5$ V and a frequency of $f = 300$ Hz; i.e., $V = V_0 sin(2\pi f t)$. Assume that $C = 1.5 \times 10^{-6}$ F. What is the amplitude of the current in the circuit?

(a) 4.2 mA
(b) 350 mA
(c) 26 mA
(d) 13 mA
(e) 2.0×10^6 A

12. Consider the circuit shown below. The voltage of the AC source is $V = V_0 sin(2\pi f t)$. If the frequency is extremely high (i.e., if f is very very large), what is the amplitude of the current in the circuit?



(a) L/R
(b) $-V/R$
(c) V/R
(d) zero
(e) VL/R

Note: Problem 13 is worth 4 points.

13. In class we did a demonstration in which a bar magnet was inserted into, or pulled out from the center of a loop of wire, and we observed the current that was induced in the wire. Which of the following principles was that demonstration designed to illustrate?

    (a) Inductance

    (b) Coulomb's law

    (c) Faraday's law

    (d) Ampere's law

    (e) Biot-Savart law

The End

Physics 241 Exam 2

1. D
2. D
3. B
4. E
5. B
6. D
7. E
8. B
9. A
10. E
11. A
12. D
13. C