Physics 114 – Practice Test Solutions for Midterm 2
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Conceptual Question 1:

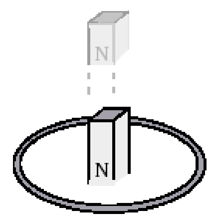
Explain the following:

(a) Is it possible for a charged particle to move through a magnetic field without experiencing a force?
(b) Is it possible for a charged particle to be at rest in the simultaneous presence of a magnetic and an electric field?
(c) Is it possible for such a particle to move through the fields without experiencing a force?
(d) What is the net force on a magnetic dipole in a uniform magnetic field?

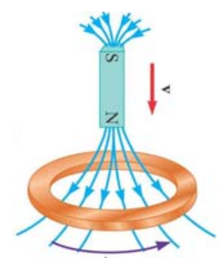
(a) Yes. If the velocity of the particle and the field are in the same direction, the magnetic force will be zero.
(b) No. A particle at rest will not experience a magnetic force but will experience an electric force and accelerate.
(c) Yes. The magnetic and electric forces may be equal in magnitude and in opposite directions.
(d) Zero. While there may be a net torque on the dipole, the net force is zero.

Conceptual Question 2:

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? Explain.

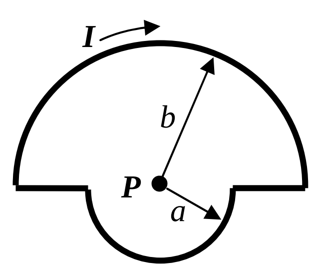


I. The current in the loop always flows in a clockwise direction.
II. The current in the loop always flows in a counterclockwise direction.
III. The current in the loop flows first in a clockwise, then in a counterclockwise direction.
IV. The current in the loop flows first in a counterclockwise, then in a clockwise direction.
V. No current flows in the loop because both ends of the magnet move through the loop.



The field of the magnet is pointing downward. Initially, as it falls towards the loop, the field and the flux through the loop is increasing. Therefore, the induced current in the loop is going to try to oppose this increase and point upward. This requires a counterclockwise current. As the magnet passes through the loop and starts to fall away, this time the field (still pointing downward) and the flux is decreasing. Now, the induced current is going to try to keep the flux the same and add to the field. This will require a clockwise current.

Problem 1:



A length of wire is formed into a closed circuit with radii *a* and *b*, as shown in the figure, and carries a current *I*. What is the magnitude and direction of the magnetic field at *P*, the center of the two semi circles?

There is no magnetic field at P created by the straight sections.

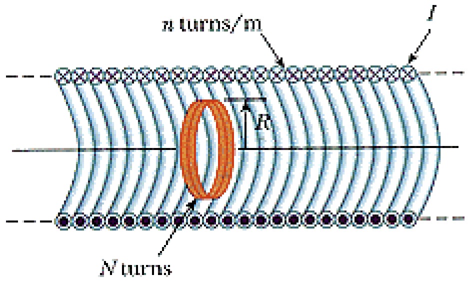
For the outer semi-circle: $B = \frac{\mu_0 I \pi}{4\pi b} = \frac{\mu_0 I}{4b}$ (directed in to the page)

For the inner semi-circle, $B = \frac{\mu_0 I \pi}{4\pi a} = \frac{\mu_0 I}{4a}$ (directed in to the page)

The total field at P is: $\boxed{B_P = \frac{\mu_0 I}{4}\left(\frac{1}{a} + \frac{1}{b}\right)}$ (directed in to the page)

Problem 2:

A long solenoid has 410 turns per meter and carries a current $I = (25.5A)(1 - e^{-1.60t})$. Inside the solenoid and coaxial with it is a coil that has a radius of 6.00 cm and consists of a total of 250 turns of fine wire (see figure). What emf is induced in the coil by the changing current? What is the direction of the induced emf?



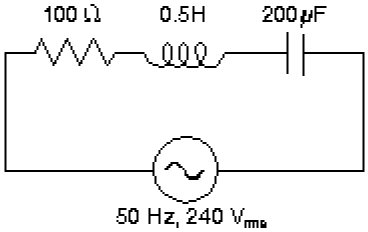
The magnetic field of the solenoid is $B = \mu_0 nI = 4\pi \times 10^{-7}(410)(25.5)(1 - e^{-1.6t})$. This field is uniform and directed horizontally. Since all the cross-sectional area of the coil, A_{coil}, has this field going through it, the flux through the coil is: $\Phi_B = BA_{coil} = 4\pi \times 10^{-7}(410)(25.5)(1 - e^{-1.6t})(\pi 0.06^2)$.

The induced emf in the coil is:

$$E = N_{coil}\frac{d\Phi_B}{dt} = 250\left[4\pi \times 10^{-7}(410)(25.5)\right](\pi 0.06^2)\frac{d}{dt}(1 - e^{-1.6t}) = (0.059V)e^{-1.6t}$$

From the current direction, the magnetic field of the solenoid is directed right to left and is increasing over time. To counteract this, the induced emf should be counterclockwise.

Problem 3:



In the circuit shown,

(a) What is the total impedance of the circuit?
(b) What is the rms current of the circuit?
(c) How much power is transferred to the resistor?
(d) What should the capacitance be changed to for maximum power transfer to the resistor?

(a) $X_L = \omega L = 2\pi(50Hz)(0.5H) = 157.1\Omega$ and

$X_C = (\omega C)^{-1} = [2\pi(50Hz)(200\mu F)]^{-1} = 15.92\Omega$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = 173\Omega$$

(b) $$I_{rms} = \frac{V_{rms}}{Z} = \frac{240V}{173\Omega} = 1.39A$$

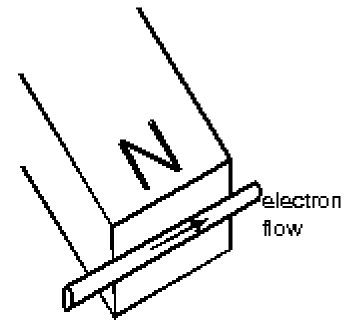
(c) $$P_R = I_{rms}^2 R = (1.39A)^2(100\Omega) = 192.4W$$

(d) For maximum power transfer, $X_L = X_C$, then,

$$\omega L = \frac{1}{\omega C} \text{ and } C = \frac{1}{\omega^2 L} = \frac{1}{(2\pi 50)^2 0.5} = 2.03 \times 10^{-5} F = 20.3\mu F$$

Multiple Choice Questions:

1. The figure shows the motion of electrons in a wire which is near the N pole of a magnet. The wire will be pushed:
   a) toward the magnet
   b) away from the magnet
   c) downwards
   d) upwards
   e) along its length



Remember that the current is in the opposite direction of electron flow. Also, the magnetic field of the magnet points away from the north pole. Applying the right hand rule to the equation, $\vec{\mathbf{F}} = I\vec{\mathbf{L}} \times \vec{\mathbf{B}}$, the force is upwards.

2. The magnetic dipole moment of a current-carrying loop of wire is in the positive z direction. If a uniform magnetic field is in the positive x direction the magnetic torque on the loop is:
   a) 0
   b) in the positive y direction
   c) in the negative y direction
   d) in the positive z direction
   e) in the negative z direction

$\vec{\boldsymbol{\tau}} = \vec{\mu} \times \vec{\mathbf{B}}$

3. The magnetic properties of materials stem chiefly from:
   a) particles with north poles
   b) particles with south poles
   c) motions of protons within nuclei
   d) proton spin angular momentum
   e) electron magnetic dipole moments

Both the orbital and spin dipole moment of electrons create magnetic properties.

4. In Ampere's law, $\oint \vec{B}.d\vec{s} = \mu_0 I$, the integration must be over any:
   a) surface
   b) closed surface
   c) path
   d) closed path
   e) closed path that surrounds all the current producing $\vec{B}$.

The path of integration need not surround all the currents.

5. A charged capacitor and an inductor are connected in series. At time $t = 0$ the current is zero, but the capacitor is charged. If T is the period of the resulting oscillations, the next time, after $t = 0$ that the energy stored in the electric field of the capacitor is a maximum is:
   a) T
   b) $T/4$
   c) $T/2$
   d) T
   e) $2T$

The energy in the capacitor oscillates at twice the frequency of the charge on the capacitor.