Principles II
Test 3

Show all work!

\[ F = qv \times B \quad F = l \times B \quad \mu_0 = 4\pi \times 10^{-7} \text{Tm/A} \quad \tau = NIA \times B \]

\[ B = \frac{\mu_0 I}{(2\pi r)} \quad B = \frac{\mu_0 I}{(2r)} \quad B(2\pi r) = \mu_0 I \]

\[ \Delta V = -\Delta \Phi_0 / \Delta t \quad \Phi = B \cos \theta \quad L = \Phi / I \quad V = -L \Delta I / \Delta t \]

\[ I(t) = \frac{V}{R} \left( 1 - e^{-t/R} \right) \quad I(t) = \int e^{-t/r} \quad \tau = \frac{L}{R} \]

1) (4 points) For the four situations shown below, determine the direction of the magnetic field at the indicated point(s).

\[ \vec{B} \quad I \]

2) (3 points) Name and describe the three types of magnetic materials.

- **Diamagnetic:** Create a smaller induced \( B \)-field opposite the direction of the external field.
- **Paramagnetic:** Create a small induced \( B \)-field parallel to the external field.
- **Ferromagnetic:** Creates a large \( B \)-field that persists after the original field is removed.

3) (3 points) We saw in class that a solid aluminum pendulum does not swing very well when placed in a magnetic field. A) Explain why.

When the pendulum swings into the magnetic field, the flux will change, which will induce current in the pendulum, creating an induced magnetic field, which will interact with the original field, causing it to stop.
B) (3 points) A pendulum that an aluminum pendulum that is shaped like a comb swings better in a magnetic field. Explain why.

If the pendulum is shaped like a comb, the induced eddy currents will be much smaller, so the magnetic moment will be much smaller, so the fields don't interact as strongly.

4) (5 points) A 3 meter long wire is carrying 1.5 A of current directed out of the paper. It is placed in a 0.065 T magnetic field, which is pointing to the right. Determine the magnitude and direction of the force on the wire.

\[ \mathbf{F} = I \mathbf{l} \times \mathbf{B} \]
\[ = (1.5)(3m)(0.065T) \]
\[ = 0.2925 \text{N \ upward \ \uparrow} \]

5) For the situation shown below, determine the direction of:

(3 points) The original magnetic field, and whether it is increasing or decreasing.

to the right, increasing

(2 points) The induced magnetic field
to the left

(2 points) The induced current
clockwise

![Diagram of magnet, Galvanometer, and coil]

6) For the 3.5 cm radius loop shown below, a 1.25 mA current is turned on in 0.0001 s. Determine A) (4 points) the magnitude and direction of the magnetic field due to the current

\[ B = \frac{\mu_0 I}{2 \pi} \text{ Into the page} \]
\[ = \frac{(4\pi \times 10^{-7})(1.25 \times 10^{-3})}{2 \times 0.035} \]
\[ = 2.24 \times 10^{-8} \text{ T} \]
B) (4 points) the magnetic flux due to the current

\[ \Phi_B = B A \cos \theta \]
\[ = (2.24 \times 10^{-8}) (\pi \cdot (0.035)^2) \cos 0 \]
\[ = 8.636 \times 10^{-11} \text{ Wb} \]

C) (4 points) the induced voltage in the loop

\[ E = \frac{\Delta \Phi_B}{\Delta t} = \frac{8.636 \times 10^{-11} - 0}{0.001} \]
\[ = 8.636 \times 10^{-7} \text{ V} \]

D) (2 points) the direction of the induced current in the loop

Counter clockwise

7) (4 points) An LR circuit consists of a 10.0-V battery, a 20.0-Ω resistor, and a 25.0-mH inductor connected in series. At what time will the current be 75% of its maximum value?

\[ I(t) = \frac{E}{R} (1 - e^{-\frac{t}{RL}}) = \frac{10}{20} (1 - e^{-\frac{t}{20/0.025}}) = 0.75 \]
\[ 1 - e^{-20025} = 0.75 \]
\[ e^{-20025} = 0.25 \]
\[ -\frac{20t}{0.025} = \ln (0.25) = -1.386 \]
\[ t = 1.00173 s \]

8) (3 points) Explain how a motor works.

When a current-carrying loop is placed in a magnetic field, the dipole of the loop will feel a torque that causes it to rotate in the field. If the direction of the current changes every half-turn, the loop will rotate indefinitely.