FINAL EXAM

Name (print)  David Nott  Name (signed)  Aug 16 2

Discussion Instructor (circle): Condella  Godfrey-Smith  Guilkey  Leong  Nott  Paul

Discussion Section #  

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

(a) Calculate the magnetic field at the center of a circular coil of 45 turns carrying a current of 1.75 A. The coil has a diameter of 35.0 cm.

\[ B = \frac{\mu_0 N I}{2 \pi R} = \frac{4 \pi \times 10^{-7} \times 45 \times 1.75}{35} = 2.83 \times 10^{-4} \text{T} \]

(b) Calculate the cyclotron frequency (in Hz) for electrons in a magnetic field of 4750 gauss.

\[ f = \frac{qB}{2 \pi \hbar} = \frac{1.6 \times 10^{-19} \times 4750}{2 \pi \times 9.11 \times 10^{-31}} = 1.327 \times 10^{10} \text{Hz} \]

(c) Imagine that the magnetic field in some region of space varies as \( B = B_0 + at + bt^2 \), where \( B_0 \), \( a \) and \( b \) are positive constants. Calculate the maximum emf that is induced at \( t = 10 \text{ s} \) in a coil of 45 turns and a diameter of 35.0 cm if placed in this region of space.

\[ E = N A \frac{dB}{dt} = N \pi \left( \frac{1}{2} \right)^2 (a + 2b t) = 45 \pi \left( \frac{35}{2} \right)^2 (a + 2b t) = 4.33(a + 2b t) \]

\[ = 4.33a + 8.66b \]

(d) If the capacitor shown has a charge of \( 45.0 \times 10^{-3} \text{ C} \) at \( t = 0 \), calculate the voltage across the capacitor at \( t = 5.00 \text{ s} \). (\( C = 4500 \mu \text{F} \), \( R = 4800 \Omega \))

\[ Q(t) = Q_0 e^{-t/RC} \quad V = \frac{Q}{C} \quad RC = 21.6 \text{ sec} \]

\[ V(t) = \frac{Q_0}{C} e^{-t/RC} = \frac{45 \times 10^{-3}}{4.5 \times 10^{-3}} \left( \frac{5}{21.6} \right) = 10 e^{-0.231} = 7.93 \text{ V} \]

(e) A wire carries a current in the direction shown. The wire and the loop are in the plane of the paper. If the magnitude of the current in the wire is decreasing with time, is the induced current in the loop clockwise or counterclockwise?

Counter-clockwise, trying to keep \( \vec{B} \) from decreasing

(f) A bolt of lightning with a peak current of 65,000 A strikes a tall metal post stuck in the ground. Calculate the peak value of the magnetic field 10.0 cm from the post.

\[ B = \frac{\mu_0 I}{2 \pi R} = \frac{2 \times 10^7 \times 65 \times 10^4}{10^2} = 1.300 \text{ T} \]