Sample Exam 4

Short Answer

1. A metal bar of length 1 m travels through a perpendicular B field with magnitude 1 T. How fast would the bar need to go to develop an emf of 1 V across its ends.
2. A uniform magnetic field passes through a square loop of wire with 5 turns. The loop has side 0.1 m and is oriented at 30 degrees with respect to the field. What is the flux through the wire? If the field drops from 5 T to 4 T in 1 minute, what emf will develop and in what direction will it point.
3. A cylindrical solenoid is 0.5 m long and has 50 turns per cm. What field is present if 1 amp flows through the wire? (Hint: Calculate using Ampere's Law). What is the energy density?
4. Compute the inductance of the solenoid in SA 3.
5. A 100mH inductor has a current given by $i=2t^2+3t+4$. What voltage develops across the inductor at t=3 sec.
6. Write Maxwell's equations and briefly explain each equation.
7. Describe the underdamped, critically damped, and overdamped solutions of the RLC circuit.
8. An emf with frequency 60 Hz and $V_0 = 300$ drives a circuit with resistance 100 Ohms and inductance 0.5 H. What are the RMS voltage, the inductive reactance X_L, the impedance Z, and the maximum and RMS current.
10. An incoming radio wave has a frequency f of 780 Khz. If the inductor in an LC circuit is 100mH, what should the capacitance be set to to tune this radio to this frequency.
11. Derive the expression for the magnitude of the magnetic field at a distance r from a long straight wire.

12. A current of 10A is distributed uniformly across a beam with a radius a. Find the magnetic field at a distance r from the center of the beam. Consider both r<a and r>a.

Problems.

1. A magnetic field is given by

$$B = B_0 \cos \omega t$$

Note that the magnitude of B changes, but not its direction. A circular loop is placed in this field and oriented at an angle θ

a. What is the magnetic flux through the loop?
b. What emf is induced? Draw a picture to indicate the direction of the induced current
c. What angle leads to the maximum induced emf?
d. Assume that θ is now 0. What electric field is present at the radius of the wire?

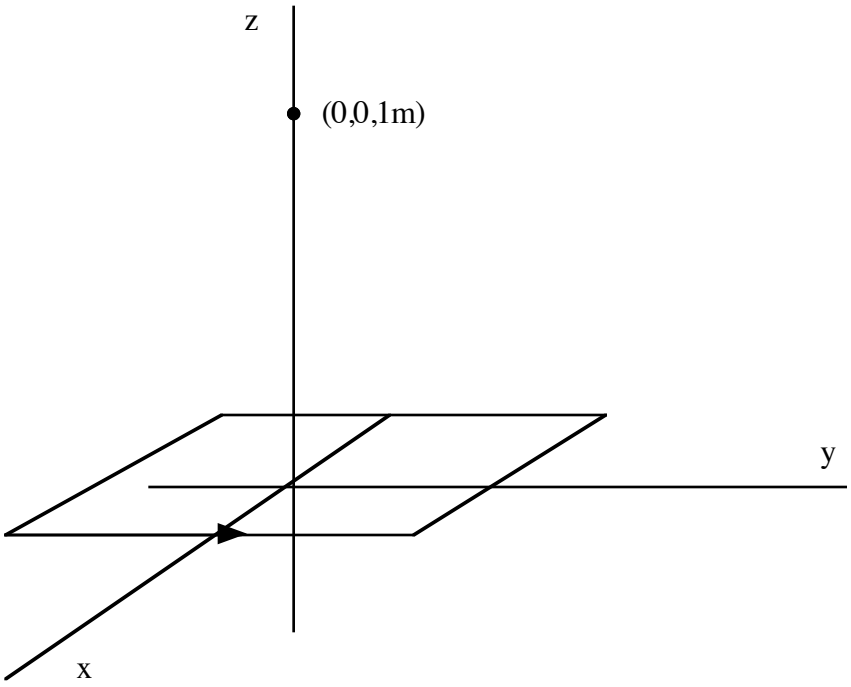
2. A circular parallel plate capacitor with radius R and separation d in an RC circuit discharges via the equation

$$q = q_0 e^{-t/RC}$$

a. What is the electric field as a function of time?
b. What is the displacement current at R/2 and R?
c. What is the induced B at at R/2 and R?

3. Consider an RLC circuit with R=10 Ohms, L = 500 mH and C=1microF.
a. Write the differential equation that describes this circuit by using Kirchoff's voltage loop rule. What is the natural osc. frequency?
b. Now consider driving this circuit. What are X_L,X_C, and Z for this circuit? Sketch the amplitude of the voltage across the capacitor as a function of the frequency.

4. A Square loop with side 1 m contains a single turn of wire. It is placed so that the center of the square is at the origin. Compute the magnetic field at a point (0,0,1m). Take the current to be 5 Amps and flowing in the counterclockwise direction as viewed from above.



4. A circular loop with radius a is centered at the origin as below. Find the magnetic field at a point (0,0,z). You may assume a current I in the clockwise direction.