PHYSICS 110B SPRING 2003

MIDTERM I

PUT YOUR NAME ON THE EXAM RIGHT AWAY!

PROBLEM 1 [25 POINTS]

A long straight wire contains a net electrical charge of λ C/m. This wire runs down the axis of an infinite solenoid of radius s_0, which is wound with n turns per meter. Calculate the total momentum and angular momentum (magnitude and direction, in both cases) carried in the fields in a length z_0 of this configuration, assuming that a current I courses through the turns of the solenoid. Angular momentum is only defined up to a chosen axis; let the axis of choice be the obvious one; i.e., the axis of the solenoid along which the wire lies.

PROBLEM 2 [25 POINTS]

An infinite straight wire carries a current I_0. A square loop of wire of side a rests with its near edge a distance a from the wire (see diagram). At $t = 0$ the current in the straight wire is switched off, and it dies away with a time-dependence of

$$I(t) = I_0 e^{-t/\alpha}.$$

If the total resistance in the square loop is R, what is the total energy dissipated by the loop as the current in the wire dies away? You may ignore the self-inductance of the loop. (Remember, of course, that the rate of energy dissipated by a resistor is $P = \varepsilon^2/R$, where ε is the emf across the resistor).

PROBLEM 3 [25 POINTS]

A voltage source $V_s(t) = V_0 \cos(\omega t)$ drives a series $L{-}R$ circuit (no capacitance in the circuit). The values of the resistance an inductance are 6Ω and 10 mH (10^{-2} Henry), respectively.

a) Assuming $V_0 = 10$ Volts, at what angular frequency ω is the amplitude of the current oscillation through the circuit exactly 1 Amp?

b) What is the average power delivered by the voltage source into the circuit?

PROBLEM 4 [25 POINTS]

A perfectly-coupled unit-gain transformer (i.e., a transformer with $L_1 = L_2 = L$ and $M = L$) is driven by a source voltage

$$V_s = V_0 \cos(\omega t).$$

Both the primary and secondary coil are encumbered by equal purely resistive loads of magnitude R. In addition, the secondary inductor is leaky, meaning it is effectively connected in parallel with a parasitic resistance R_p (see diagram).

To make the following calculation more tractable, please assume that $R_p = R$, and that the oscillation frequency is set so that $\omega L = R$.

Your task: solve for the amplitude I_L of the current oscillation through the load of the secondary coil, as a function of V_0 and R.