Exercise Sheet 12

Discussion 3.12.2025

Exercise 1 - Impedance

a) Find the complex impedance of a coil with self-inductance L and resistance R (of the wire in the coil) in parallel with a capacitor having an imperfect dielectric equivalent to a series resistance of also R.

b) Find the value of R which makes the above impedance purely resistive (completely real) at all frequencies.

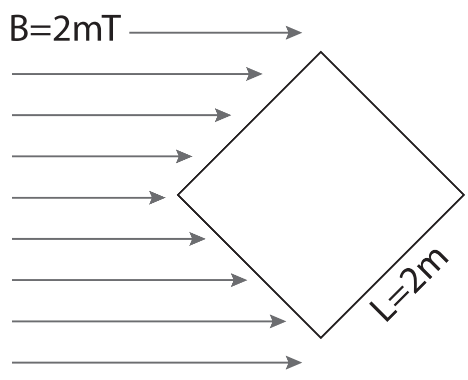
c) Find a value of ω which makes the impedance purely resistive for all values of R.

Exercise 2 - Resonance

Consider an LCR circuit in series. In the lecture the current (or phase) resonance was derived. Using that the circulating charge is given by $\frac{I}{\omega}$ derive the charge resonance, i.e. the frequency for which the charge is largest.

Exercise 3 - Mu-Metal

A mu-metal box with $\mu_r = 10^5$ is placed in a homogeneous magnetic field of 2 mT as shown in the figure to the right. How thick does the mu-metal have to be, to shield the magnetic field completely inside the box?



Exercise 4 - Hysteresis

A ferromagnetic material is inserted and kept in a solenoid where you pass a current. By changing the current, you change the H field generated by the solenoid from an initial value of $+h_0$ to $-h_0$, and then you come back to the initial one. If you plot the magnetization M as a function of the H field you have applied you obtain the graph on the left side ($m_r = 200\ A/m$, $m_s = 300\ A/m$, $h_s = 1000\ A/m$).

a) Describe this typical trend, explaining the physical situation in the important points of the hysteresis curve.

b) We can simplify the hysteresis curve as in the figure on the right side. Use this simplification to evaluate the coercive H field. [*Hint: the coercive field is defined in the B(H) plot*]

c) Determine the work done per unit volume on the magnet during the whole cycle. How is this energy dissipated?