MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.013 Electromagnetics and Applications

Quiz 1 Closed book, no calculators

Please note the formulas provided on a separate sheet. There are ***4 problems*** *on two pages. For full credit, please* ***simplify*** *all expressions,* ***circle and dimension your answers****, and present numerical answers to the extent practical without a calculator or tedious computation. You may leave natural constants in symbolic form (π, ε_o, h, e, etc.). You may keep the quiz questions.*

Problem 1. (34/100 points)

A uniform plane wave in an unusual gaseous medium characterized by μ,ε is represented by:

$$\bar{E} = 2\,\hat{x}\cos(t+z) \text{ and } \bar{H} = \hat{y}\sin(t+z+\frac{\pi}{2}).$$

In each case below please briefly indicate your method, equations, or reasoning.
What are the numerical values for:

a) The wave velocity v and direction [m/s]?

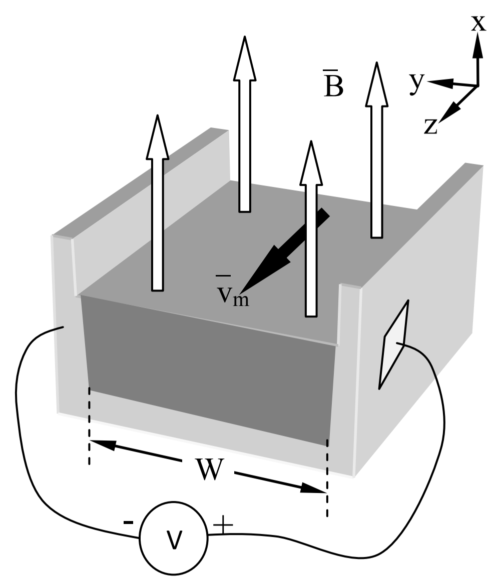
b) The time average wave intensity I [W/m^2]?

c) The permeability μ [H/m] for this medium?

d) The pressure P_m [N/m^2] the wave exerts when normally incident ($\theta_i = 0$) on a perfectly reflecting mirror?

Problem 2. (18/100 points)

A factory measures the velocity v_m [m/s] of molten metal running down an insulating sluice of width W by measuring the voltage V across the width of the channel produced by the illustrated uniform vertical magnetic field B. What is the velocity $\bar{v}_m$ in terms of the other given parameters? Briefly explain your reasoning, including the direction of $\bar{v}_m$ (see illustration).



Please turn over for Problems 3 and 4

Problem 3. (20/100 points)

What constraints are imposed on $\overline{H}_{//}$ in free space at the flat surface of a medium having $\sigma = 0$ and $\mu = \infty$? Briefly explain your reasoning.

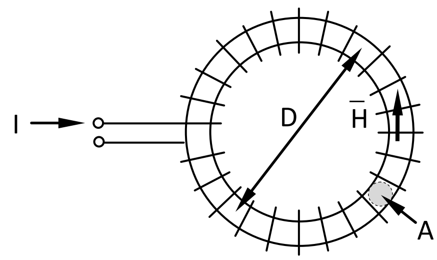
Problem 4. (28/100 points)

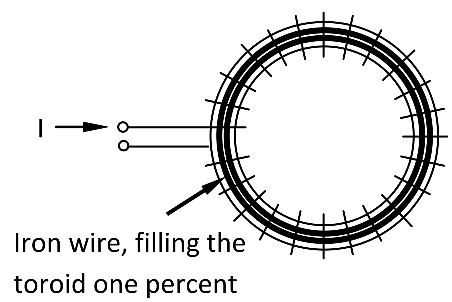
The illustrated inductor consists of N turns of wire uniformly wound around a thin hollow toroid with a major diameter of D to produce an inductance of L [Henries]. The toroid cross-sectional area is A, as illustrated, and you may neglect any fields outside the toroid.

a) What is H inside the toroid when the current through the coil is I Amperes?

b) What is the approximate inductance L of this inductor?

c) The core of this coil is now one-percent filled with many turns of iron wire having $\mu = 1000\mu_o$, as illustrated. What now is the inductance L?





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