PHYSICS 515B

ELECTROMAGNETIC THEORY

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Fall 2025

Homework 2 (due Wednesday, October 6)

Problem 1: (a) Show that for a system of current-carrying elements in empty space, the total energy in the magnetic field is

$$W = \frac{1}{2c^2} \int d^3x \int d^3x' \, \frac{\mathbf{J(x)} \cdot \mathbf{J(x')}}{|\mathbf{x} - \mathbf{x'}|} \, ,$$

where $\mathbf{J(x)}$ is the current density.

(b) If the current configuration consists of n circuits carrying currents I_1, I_2, I_3,..., I_n, show that the energy can be expressed as

$$W = \frac{1}{2} \sum_{i=1}^{n} L_i \, {I_i}^2 + \sum_{i=1}^{n} \sum_{j>i}^{n} M_{ij} I_i I_j \, .$$

Exhibit integral expressions for the self-inductances (L_i) and the mutual inductances (M_{ij}).

Problem 2: Jackson 6.11

Problem 3: Jackson 6.16

Problem 4: Jackson 6.20 (a) and (b).