Learning Objective: Ampere's Law

Problem 1. Consider an infinite line carrying current I_1 in the $+z$ direction is placed along the z-axis. Another infinite line carrying current I_2, in the same direction as I_1, is located at $x = a$ across the x-axis, where $a > 0$.

(a) Determine the magnetic field $\mathbf{H}$ as a function of x using Cartesian coordinate.

(b) Determine the magnetic flux density $\mathbf{B}$ as a function of x using Cartesian coordinate.

(c) Suppose I_2 flows in the opposite direction as I_1, determine the magnetic field $\mathbf{H}$ as a function of x using Cartesian coordinate.

Problem 2. Consider an infinitely long cylindrical conductor of radius $r = a$ cm is placed along the z-axis. A current in the $+z$ direction flows through the cylindrical conductor, where the current density is given by

$$J(\rho) = -2 \exp\left(-\frac{\rho}{z}\right) \text{ A/cm}^2$$

where $\rho > 0$ and $z = 2$ cm.

(a) Determine the magnetic field $\mathbf{H}$ as a function of ρ using cylindrical coordinate.

(b) Suppose the same current flows in the $-z$ direction, determine the magnetic field $\mathbf{H}$ as a function of ρ using cylindrical coordinate.

Learning Objective: Inductance of a Straight Coil

Problem 3. Consider a solenoid with 10 cm long, 1 mm in diameter, and 1000 terns of wire. The core of the solenoid consists a ferromagnetic material with a relative permeability of 500.

(a) Determine the magnitude of magnetic field $|\mathbf{H}|$ within the solenoid core.

(b) Determine the magnitude of the magnetic flux Φ within the solenoid core.

(c) Determine the inductance of the solenoid.

(d) Suppose this solenoid is broke from the middle, determine the inductance of this solenoid.