

8. Magnetostatics

Self-test questions

1. (a) From the Biot-Savart law, derive the magnetic field $\mathbf{B}(\mathbf{x})$ of a long straight wire with current I .
(b) From Ampère's law, derive the magnetic field $\mathbf{B}(\mathbf{x})$ of a long straight wire with current I .
2. From Ampère's law, derive the magnetic field $\mathbf{B}(\mathbf{x})$ inside a solenoid. Also, describe \mathbf{B} outside the solenoid.
3. A current I flows in a conducting slab, uniformly distributed over the cross section. Let δ be the thickness of the slab. Determine $\mathbf{B}(\mathbf{x})$ above, below, and inside the slab. Verify that $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$.
4. A current I flows in a square loop of wire (sides ℓ) in the xy plane centered at the origin. Describe $\mathbf{B}(\mathbf{x})$ for (a) \mathbf{x} on the z axis with $z \gg \ell$, and (b) \mathbf{x} in the xy plane at distance r from the z axis, with $r \gg \ell$.
5. The Tevatron accelerator at Fermilab contains protons (and antiprotons) at energy $E = 1$ TeV in a ring of radius 1 km. What is the strength of the main magnetic field?