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ENGS123 Electricity and Magnetism - Homework 10

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Problem 1

A long solenoid has 15 turns per centimeter. What current must we put through its windings if we wish to achieve a magnetic field of $5.0 \cdot 10^{-2}$ in its interior?

$$B = \mu_0 n I \implies I = \frac{5.0 \cdot 10^{-2}}{1.26 \cdot 10^{-6} \cdot 1500} \approx 26.5A$$

Problem 2

Figure shows a "solenoid" made of one turn of a sheet of copper. The solenoid has a length of $20cm$, and the current flowing around it is $2.0 \cdot 10^3 A$. What is the magnetic field in this solenoid? Assume that the current is uniformly distributed over the sheet of copper, and treat the solenoid as very long.

$$B = \mu_0 n I = 1.26 \cdot 10^{-6} \cdot \frac{1}{0.2} \cdot 2.0 \cdot 10^3 \approx 1.26 \cdot 10^{-2} T$$

Problem 3

A long solenoid of n turns per unit length carries a current I, and a long, straight wire lying along the axis of this solenoid carries a current I. Find the net magnetic field within the solenoid, at a distance r from the axis. Describe the shape of the magnetic field lines.

$$B_{\text{solenoid}} = \mu_0 n I, B_{\text{wire}} = \frac{\mu_0 I}{2\pi r} \implies B = \sqrt{B_{\text{solenoid}}^2 + B_{\text{wire}}^2} = \mu_0 I \sqrt{n + \frac{1}{4\pi^2 r^2}}$$

The magnetic field of the solenoid is along the axis, but the magnetic field by the wire are along the plane perpendicular to the axis. The total magnetic field lines are slightly deflected from the axis towards outside.

Problem 4

Two very long straight wires carry currents I at right angles. One of the wires lies along the x axis; the other lies along the y axis (see Fig.). Find the magnetic field at a point in the x–y plane in the first quadrant.

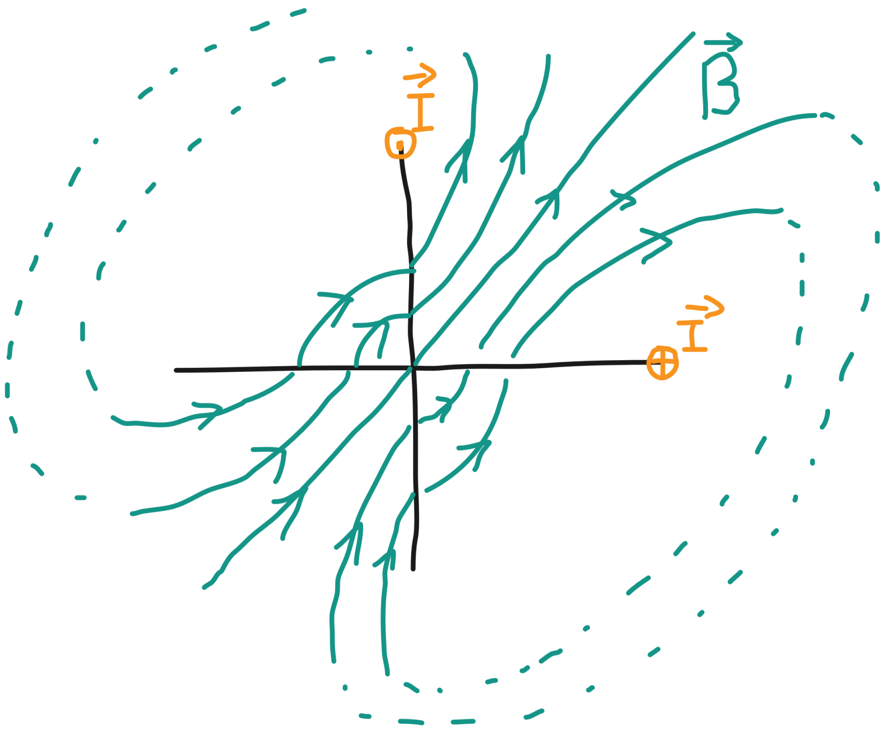
Denote the positive z axis the direction towards us, and the negative going away from us. The magnetic field is in the z axis.

$$B = \frac{\mu_0 I}{2\pi y} - \frac{\mu_0 I}{2\pi x}$$

Problem 5

Two rings of the same radius $0.20m$ are placed at right angles (see Fig.). The rings carry equal currents of $10A$. What is the magnitude of the magnetic field at the center of this arrangement of rings? Draw a diagram showing the direction of this magnetic field.

$$B_1 = B_2 = \frac{\mu_0 I}{2R} \implies B = \sqrt{2}\frac{\mu_0 I}{2R} = \frac{1.26 \cdot 10^{-6} \cdot 10}{0.2\sqrt{2}} \approx 4.45 \cdot 10^{-5} T$$



Problem 6

A long, straight wire is bent into a circular loop of radius R near its midpoint (see Fig. 29.49). The wire carries a current I. What are the magnitude and direction of the magnetic field at the center of the loop?

The magnetic field will be perpendicular to the plane and directed away from us.

$$B = \frac{\mu_0 I}{2R} - \frac{\mu_0 I}{2\pi R} = \mu_0 I \frac{\pi - 1}{2\pi R}$$

Problem 7

A long solenoid has been placed inside another long solenoid of larger radius (see Fig.). The solenoids are coaxial, and both have the same number $n$of turns per unit length and the same current I. What is the formula for the magnetic field in the region within the smaller solenoid? Between the smaller and the larger solenoid?

$$B_{\text{center}} = 2\mu_0 nI, B_{\text{between}} = \mu_0 nI$$