Exploration 2 Helmholtz Coil

Force and Torque on a Magnetic Dipole

W07D2
Announcements

Week 7:
Problem Set 6 Due Wed 11 pm

Exam Regrade Requests due Week 7 Friday

Week 8: Enjoy the Break

Week 9:
Week 9 LS 1 and LS 2 due Sunday at 11 pm
Week 9 LS 3 and Mid-Semester Survey due Tuesday at 11 pm
Problem Set 8 Due Wed 11 pm
Summary: Magnetic Dipoles

No Magnetic Point Charges: \( \oint_S \mathbf{B} \cdot d\mathbf{A} = 0 \)

Magnetic Dipole Moment: \( \vec{\mu} \equiv I A \hat{\mathbf{n}} \equiv I \overline{\mathbf{A}} \)

Torque: \( \vec{\tau} = \vec{\mu} \times \mathbf{B}_{\text{ext}} \)

Potential Energy: \( U(\theta) = -\vec{\mu} \cdot \mathbf{B}_{\text{ext}} \)

Force: \( \vec{F} = -\nabla U = \nabla ( \vec{\mu} \cdot \mathbf{B}_{\text{ext}} ) \)

Special case: \( \vec{\mu} = \mu_z \hat{k} \Rightarrow F_z = \mu_z \frac{\partial B_z}{\partial z} \)
Exploration 2: Magnetic Dipole in Helmholtz Coil

The experimental apparatus consists of two coils connected to a power supply along with a tube in which a small dipole magnet hangs from a spring that can be moved by a rod. The coils can be connected to a power supply that produces a current in the coils that creates a magnetic field.
CQ.: Magnetic Dipole in Helmholtz Coil

A dipole is initially pointing along the positive x-direction and located above the two coils (z > 0). A short time later, the dipole will feel:

1. a force but not a torque.
2. a torque but not a force.
3. both a torque and a force.
4. neither force nor torque.
A dipole is initially pointing along the positive z-direction and located at the center of an anti-Helmholtz coil (z = 0), with the z-component of the magnetic field shown in the figure on the lower right. A short time later the dipole will feel

1. a force but not a torque.
2. a torque but not a force.
3. both a torque and a force.
4. neither force nor torque.
Exploration 2 Objectives

• In this exploration we would like you to investigate:

• the magnetic field associated with a variety of coils connections;

• the torque on the magnetic dipole and direction of the force on the dipole when the dipole is placed along different points along the central axis for a two coil connections, the “Helmholtz” and “Anti-Helmholtz” configurations.
Exploration 2 Start-up Instructions

Open Week 7 chapter and select Exploration 2 Helmholtz Coil.

Move to Objective 1 and start the exploration.