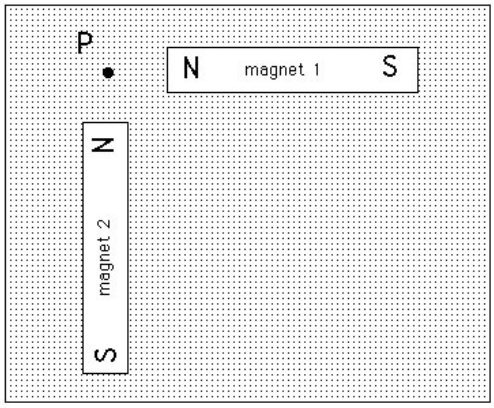
Magnetic Field
Challenge Problems

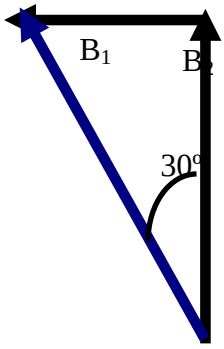
Problem 1:



Consider two bar magnets placed at right angles to each other, as pictured at left.

(a) If a small compass is placed at point P, what direction does the painted end of the compass needle point?

(b) If the compass needle instead pointed 15 degrees clockwise of where you predicted in (a), what could you qualitatively conclude about the relative strengths of the two magnets?



Problem 2:

(a) Can a constant magnetic field set into motion an electron which is initially at rest? Explain your answer.

(b) Is it possible for a constant magnetic field to alter the speed of a charged particle? What is the role of a magnetic field in a cyclotron?

(c) How can a current loop be used to determine the presence of a magnetic field in a given region of space?

(d) If a charged particle is moving in a straight line through some region of space, can you conclude that the magnetic field in that region is zero? Why or why not?

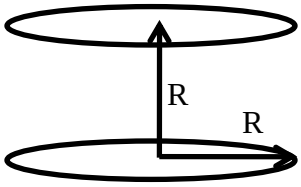
(e) List some similarities and differences between electric and magnetic forces.

Problem 3:

The magnitude of the component of a magnetic field along the axis of a coil with N turns to be given by:

$$B_{axial} = \frac{N \mu_0 I R^2}{2} \frac{1}{(z^2 + R^2)^{3/2}}$$

where z is measured from the center of the coil.



As pictured at left, a Helmholtz coil is created by placing two such coils (each of radius R and N turns) a distance R apart.

(a) If the current in the two coils is parallel (Helmholtz configuration), what is the magnitude of the magnetic field at the center of the apparatus (midway between the two coils)? How does this compare to the field strength at the center of the single coil configuration (e.g. what is the ratio)?

(b) In the anti-Helmholtz configuration the current in the two coils is anti-parallel. What is field strength at the center of the apparatus in this situation?

(c) Consider coils that have a radius R = 7 cm and N = 168 turns. Suppose I = 0.6 A runs in the single coil and 0.3 A runs in each in Helmholtz and anti-Helmholtz mode. What, approximately, are the largest on-axis fields we should expect in these three configurations? Where (approximately) are the fields the strongest?

8.02SC Physics II: Electricity and Magnetism

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