Tutorial 09

Magnetic Field

PHY 1202

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Lecture 08 Review

- All magnets have two poles: North and South with like poles repel each other and unlike poles attract each other.

- Magnetic poles are always found in pairs and isolated magnetic poles, or magnetic monopoles, have never been found. Although they are predicted to exist in theory.

- The source of the magnetic field is from moving electric charges. In fact, even the electron has a magnetic dipole that can generate tiny magnetic field due to its spin.

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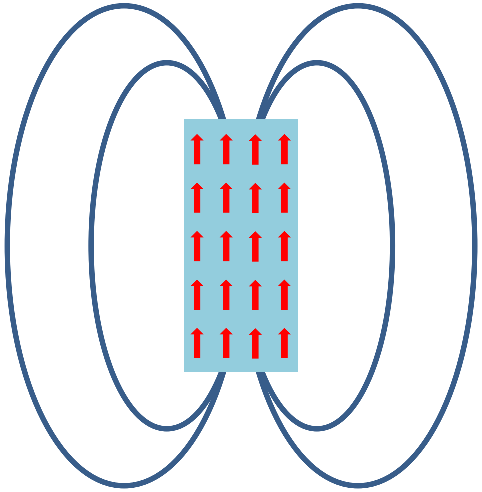
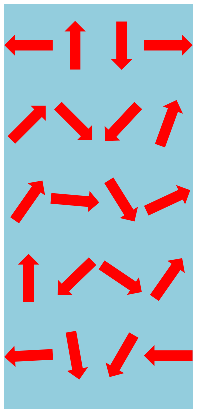
Lecture 08 Review

- Permanent magnets have their electrons/molecules add together to give a net magnetic field.
- In other materials, the magnetic fields of the electrons/molecules cancel out, giving no net magnetic field surrounding the material.





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Lecture 08 Review

- To define the magnitude and direction of an unknown magnetic field, we will need a moving test charge.

- Magnetic field **B** is defined in terms of the force $\mathbf{F_B}$ acting on a test particle with charge *q* moving through the field with velocity **v**.

$$\boxed{\vec{F}_{\mathbf{B}} = q\vec{v} \times \vec{B}}$$

- The SI unit of magnetic field is tesla, where 1 T= 1 N/(A-m).

- The magnetic field of a magnet starts from the North pole and ends in the South pole.

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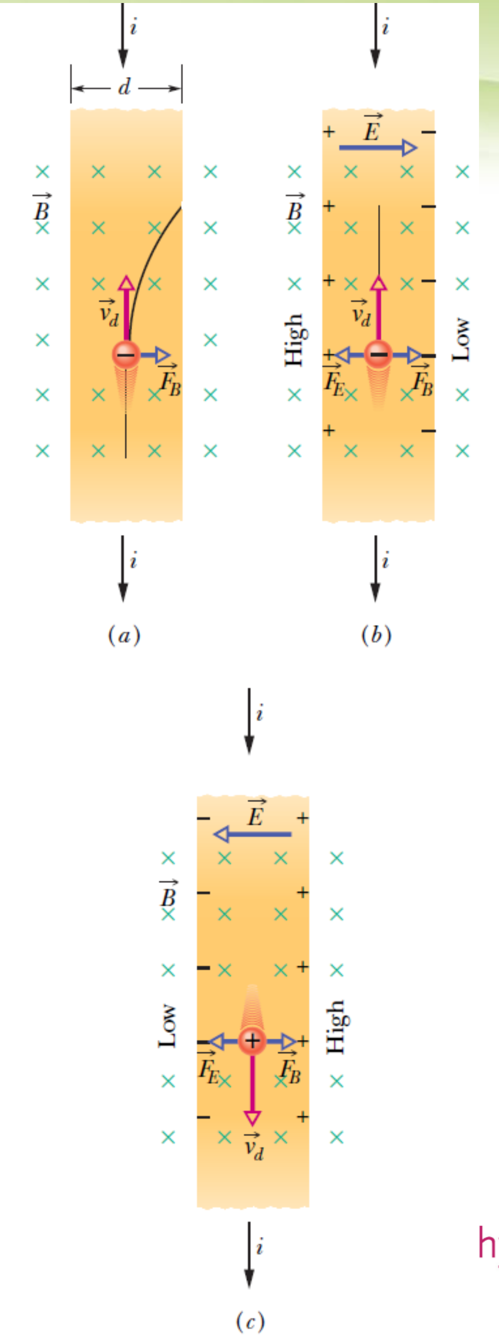
Lecture 08 Review

- When a conducting strip carrying a current i is placed in a uniform magnetic field B, some charge carries build up on one side of the conductor, creating a potential difference V, the Hall potential difference, across the strip. The polarities of the sides indicate the sign of the charge carriers. This is refers to as the Hall Effect.
- We can measure the drift velocity and the carrier density with the Hall effect.
- With

$$v_d = \frac{J}{ne} = \frac{i}{neA} \qquad n = \frac{Bi}{Vle},$$



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Lecture 08 Review

- When a charged particle moving with a constant velocity perpendicular to a uniform magnetic field will circulate in the field with a angular frequency

$$r = \frac{mv}{|q|B} \qquad \text{(radius).}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi}{v}\frac{mv}{|q|B} = \frac{2\pi m}{|q|B} \qquad \text{(period).}$$

$$f = \frac{1}{T} = \frac{|q|B}{2\pi m} \qquad \text{(frequency).}$$

$$\omega = 2\pi f = \frac{|q|B}{m} \qquad \text{(angular frequency).}$$

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Lecture 08 Review

- A straight wire carrying a current i in a uniform magnetic field experiences a sideway force

$$\vec{F}_B = i\vec{L} \times \vec{B}$$

- A coil carrying a current in a uniform magnetic field will experience a torque given by

$$\vec{\tau} = \vec{\mu} \times \vec{B} \rightarrow \tau = \mu B \sin\theta$$

- Here μ is the magnetic dipole moment of the current loop, that is a function of the current i, area A and the number of loops N.

$$\mu = NiA$$

- This is similar to the electric dipole moment in an electric field.

Potential Energy of the Magnetic Dipole in a Magnetic Field	$U = -\vec{\mu} \cdot \vec{B}$

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Halliday/Resnick/Walker
Fundamentals of Physics 8th edition

Classroom Response System Questions

Chapter 28 Magnetic Fields

Interactive Lecture Questions

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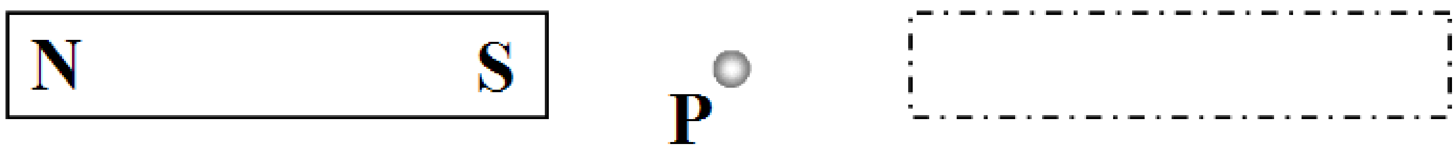
Q1: 28.2.1. Consider the two rectangular areas shown with a point P located at the midpoint between the two areas. The rectangular area on the left contains a bar magnet with the south pole near point P. The rectangle on the right is initially empty. How will the magnetic field at P change, if at all, when a second bar magnet is placed on the right rectangle with its <u>south</u> pole near point P?



a) The direction of the magnetic field will not change, but its magnitude will decrease.

b) The direction of the magnetic field will not change, but its magnitude will increase.

c) The magnetic field at P will be zero tesla.

d) The direction of the magnetic field will change and its magnitude will increase.

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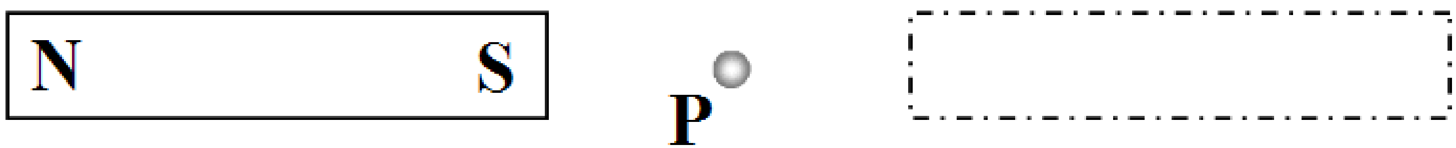

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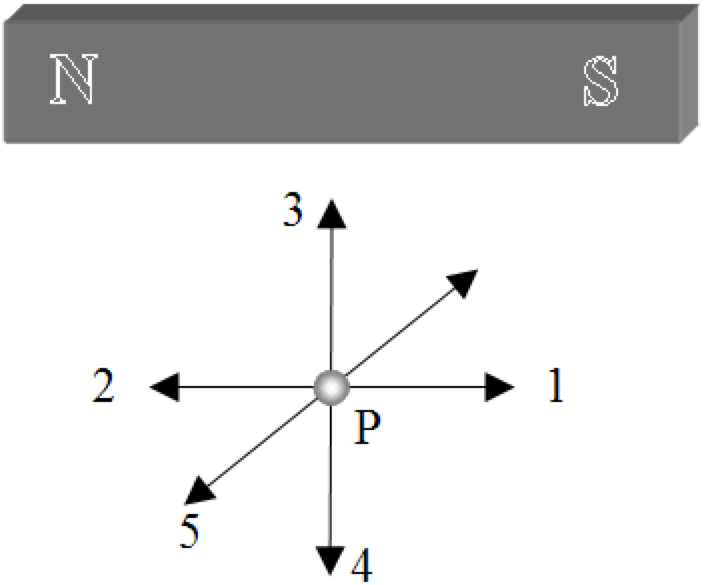
Q2: 28.2.3. What is the direction of the magnetic field at the point P, directly below a point at the center of the magnet? The numbered arrows represent various directions. Direction "1" is to the right, "2" to the left, "3" is upward, "4" is downward, and "5" is toward you.



a) 1

b) 2

c) 3

d) 4

e) 5

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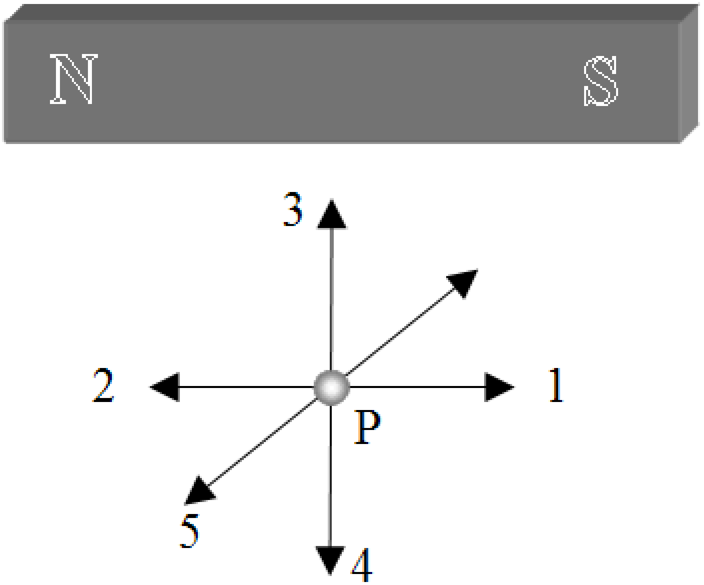

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Q3: 28.2.4. Two rods are resting on a table. Although they appear to be identical, one is a permanent magnet and the other is made from soft iron and is not permanently magnetized. Which one of the following methods is most likely to reveal which rod is the magnet and which is the soft iron?

a) Take one of the rods and touch it to each end of the other rod.

b) Use a magnetic monopole to find the end of one of the rods that repels it.

c) Move a compass along each rod to see if the compass needle behaves as it should in a magnetic field.

d) There is no way to tell the difference between the two rods.

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Q4: 28.3.1. A negatively-charged particle travels parallel to magnetic field lines within a region of space. Which one of the following statements concerning the force exerted on the particle is true?

a) The force is directed perpendicular to the magnetic field.

b) The force is perpendicular to the direction in which the particle is moving.

c) The force slows the particle.

d) The force accelerates the particle.

e) The force has a magnitude of zero newtons.

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Q5: 28.3.3. Which one of the following statements concerning the magnetic force on a charged particle in a magnetic field is true?

a) The magnitude of the force is largest when the particle is not moving.

b) The force is zero if the particle moves perpendicular to the field.

c) The magnitude of the force is largest when the particle moves parallel to the direction of the magnetic field.

d) The force depends on the component of the particle's velocity that is perpendicular to the field.

e) The force acts in the direction of motion for a positively charged particle.

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Q6: 28.5.1. Two metal bars, A and B, are identical in all ways, except that bar B has twice the width of A. The bars are parallel to each other, but far apart from each other, in a uniform magnetic field and carry the same amount of current in a direction perpendicular to the field. How does the Hall voltage of bar B compare to that of bar A?

a) The Hall voltage for bar B will be four times greater than that of bar A.

b) The Hall voltage for bar B will be two times greater than that of bar A.

c) The Hall voltage for bar B will be the same as that of bar A.

d) The Hall voltage for bar B will be one-half that of bar A.

e) The Hall voltage for bar B will be one-fourth that of bar A.

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$$V_H = Ed = v_d Bd = \frac{iBd}{neA} = \frac{iB}{nle}$$

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Q7: 28.7.1. Ernest O. Lawrence, of the University of California, Berkeley, invented the cyclotron in 1929. A more modern version was completed in 1961 at the Lawrence-Livermore Laboratory that has a radius of 88 inches. What is the frequency of circular motion at the "88-incher" if protons are circulating in a magnetic field of 0.48 T?

a) 1.4×10^6 Hz

b) 4.5×10^6 Hz

c) 7.3×10^6 Hz

d) 3.6×10^5 Hz

e) 9.7×10^4 Hz

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$$f = \frac{1}{T} = \frac{|q|B}{2\pi m} = \frac{(1.602\times10^{-19})(0.48)}{2\pi(1.672\times10^{-27})} = 7.32\ \text{MHz}$$

d) 3.6×10^5 Hz

e) 9.7×10^4 Hz

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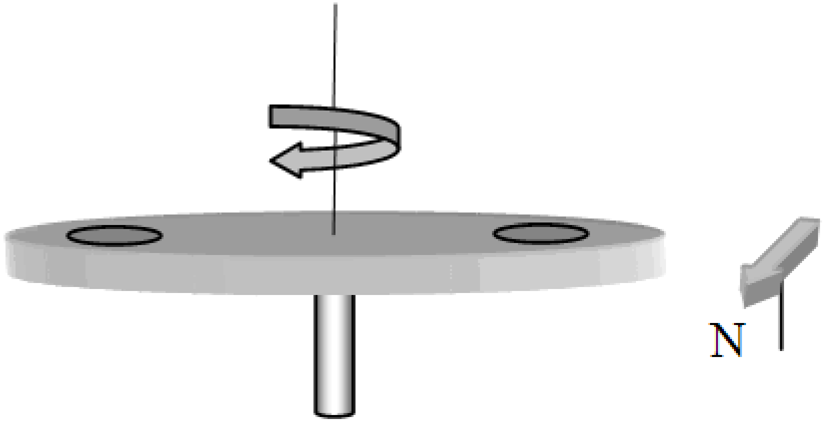
Q8: 28.8.3. Small charged disks are inserted into a larger, insulating disk. A compass is placed near the larger disk and points due north as shown. The larger disk is then rotated uniformly counterclockwise (as viewed from above). What, if anything, will happen?

a) The north end of the compass will move toward the large disk as it rotates.



b) The north end of the compass will move away from the large disk as it rotates.

c) The compass will not be affected by the motion of the large disk.

d) The north end of the compass will oscillate toward and away from the large disk as it rotates.

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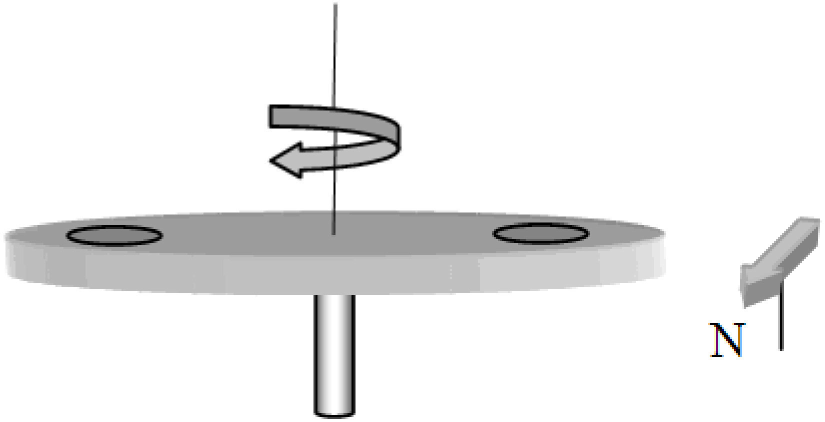

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Q9: 28.10.1. Consider the relationships between the directions of the torque acting on a magnetic dipole in a magnetic field, the magnetic field, and the magnetic dipole moment. Which one of the following statements regarding these directions is true?

a) The torque is parallel to both the magnetic field and the dipole moment.

b) The torque is perpendicular to the magnetic field, but parallel to the dipole moment.

c) The torque is parallel to the magnetic field, but perpendicular to the dipole moment.

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