Lecture 28  iq24

1. Magnetic force on a current segment. Ch21 h1 006
   - Force on || wires (same direction lead to attraction, opposite leads to repulsion)
2. Current loop in presence of const B.
   - Net force vanishes.
   - Torque on a loop, when B is in the plane of the loop. Ch21. h1.010-012
   - General case: Ch21: h1, 013-015
3. Circular motion in the plane perpendicular to a constant B field. Ch21-h2-03.
   - Period independent of r and v.
   - Cyclotron
   - Bending electrons in the magnetic field
4. Hall effect: h2: 006-010
   - Experiment which determines the sign of the carrier charge.
   - Direction of Hall current
   - Calculate the Hall voltage
   - Relationship between number density and the mass density.
     - One mole has
       - the molar mass M, and
       - has #-free electrons=(# valence electrons)NA.

Announcement:

**Learning module:**
Feedback will be incorporated into the lecture.

The learning modules will count as part of the homework score: instead of homework accounting for 15%, we now have homework at 12% and leaning modules at 3%.

**Feedback on homework:** This feedback will be used as the basic content for discussion sessions. In order to encourage participation, we have made HW feedback part of the iq clicker credit:

- iq clicker now counts for 5%,
- while feedback counts for 2%.

The latter is an easy 2%, as all you need to do is tell us which problem you found most confusing on a particular assignment and why. The feedback will be due on the same evening the homework is due, but the due time will be 11:50 to give those last-minute types a chance to enter feedback after completing the homework.
Magnetic force: field acts a force on the charge $\mathbf{q}$.

$$ \mathbf{F} = q \mathbf{E} \times \mathbf{B} $$

$$ \mathbf{F} = q \mathbf{v} \times \mathbf{B} $$

Magnetic force on a current segment: HW #8.1 #1 #16

- **Wire**

$$ \mathbf{F} = \oint \mathbf{B} \cdot d\mathbf{l} $$

$$ \mathbf{F} = \int A \mathbf{B} \cdot d\mathbf{l} $$

$$ \mathbf{F} = \int \mathbf{B} \cdot d\mathbf{l} $$

$$ \mathbf{F} = \int \mathbf{B} \cdot d\mathbf{l} $$

$$ \mathbf{F} = \int \mathbf{B} \cdot d\mathbf{l} $$

**Current loop in a constant $\mathbf{B}$**

$$ \mathbf{F}_1 = Ia\mathbf{B} \quad \bigcirc $$

$$ \mathbf{F}_2 = Ia\mathbf{B} \quad \bigcirc $$

$$ \mathbf{F}_3 = Ia\mathbf{B} \quad \bigcirc $$

$$ \mathbf{F}_4 = 0 $$

Check 4V Repulsive
\[ F_{\text{total}} = F_1 + F_3 = IaB - IaB = 0 \]

Torque about midline \( AB \): \( \text{Vx is from the baseline loop} \)

\[ \tau = F_b = (IaB) \cdot b = Iab \cdot b, \mu = IA = Iab. \]

Intuitive picture:

**General case:** \( k_1 = 0.3 \), \( k_2 = 0.1 \)

\[ \tau = \mu \times B \] (Induction)

**Geometry:** See figure. \( \vec{B} \) is in xy plane, \( \alpha < 90^\circ \)

\[ \vec{B} = B \left( \hat{x} \cos \alpha + \hat{y} \sin \alpha \right) \]

\[ \vec{\mu} = \mu \hat{z} \]

\[ \tau = \vec{\mu} \times \vec{B} = \mu B \]

\[
\begin{vmatrix}
\hat{i} & \hat{j} & \hat{k} \\
0 & 1 & 0 \\
-\sin \alpha & 0 & \cos \alpha
\end{vmatrix}
\]
3. Circular motion: Force due to $B$ on qv

Chapter 26.4 - Given: $B$ - constant and uniform

Find direction of the force at $P$, $P_1$ and $P_2$

Let me draw it at $P$:

\[ \begin{align*}
\vec{F}_p &= \frac{q v B}{r} \quad \text{or} \quad \vec{F}_p = \frac{m v^2}{r} \quad \text{or} \quad \vec{F}_p = \frac{q v B}{r} \\
\end{align*} \]

\[ \text{Period is independent of } v, r. \]

\( \omega = \frac{2\pi}{T} = \frac{q B}{B m} \) (cyclotron)

Alternative: $\Delta t \Rightarrow E > 0$, $E < 0$

$\Delta t \Delta q = q v \sin \omega t$
4. Hall effect: Determine the sign of charge carriers.

a) \( \mathbf{B} \rightarrow \mathbf{f} = \mathbf{I} \times \mathbf{B} \)

If carriers have + charge:

\[ A \xrightarrow{++} \xrightarrow{+-} \xrightarrow{-+} \xrightarrow{--} \]

\[ \mathbf{I} \text{ Hall} \uparrow \]

If carriers have - charge:

\[ A \xrightarrow{-+} \xrightarrow{+-} \xrightarrow{++} \xrightarrow{--} \]

\[ \mathbf{I} \text{ Hall} \downarrow \]

b) \( V \text{ Hall} = \text{After equilibrium:} \)

For case 1: Static charged charge exists \( E \uparrow \)

Potential at \( B \) is given. Take a test charge to be pushed by \( F = q \mathbf{B} \) to leave potential from \( A \) to \( B \)

\[ V_B - V_A = \frac{q \mathbf{B}}{q} = \frac{q \mathbf{B} \cdot \mathbf{L}}{q} = q \mathbf{B} \cdot \mathbf{L} \]

\[ \text{Case 2: } E \downarrow \]

\[ V_A - V_B = q \mathbf{B} \cdot \mathbf{L} \]

Determinant of \( \sigma \): \( \mathbf{I} = \mathbf{B} \times i = \frac{q}{m} n \mathbf{A} \)

\[ \sigma = \frac{I}{q \mathbf{A}} \]

Exercise:

\[ n = \text{number of electrons} \]

\[ V = \text{vol} \]

\[ \mathbf{n} \] = number of atoms

\[ \frac{n}{\text{vol}} \]

\[ \frac{1}{2} \mathbf{n} = \frac{2N_A}{M} \]

\[ \eta = \frac{2N_A}{M} \]