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)N_A.

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 baic 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 exerts a force on the source

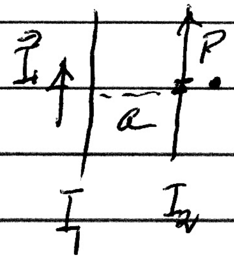
$\vec{B}$ $q\vec{v}$

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

$$\Delta\vec{F} = I\Delta\vec{l} \times B$$

1. Magnetic force on a current segment: HW ch21 h1 006

• ∥ wire



at P: $B_p^{I_1}$ ⊗

$$\Delta F^{B \leftarrow \text{due to } I_1}_{I_2 \Delta l} = I_2 \Delta \vec{l} \times B_p^{I_1}$$

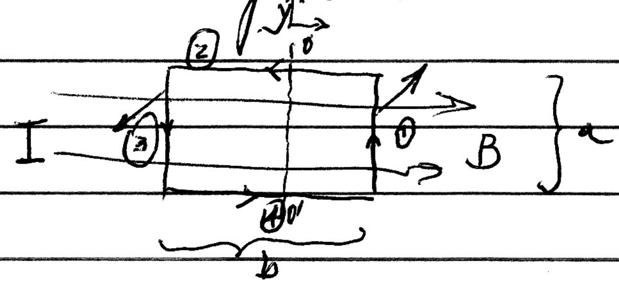
$\uparrow I_2 \times \odot$ ⟸

$$\Delta F = (I_2 \Delta l)\left(\frac{\mu_0 I_1}{2\pi a}\right)$$

$$\frac{\Delta F}{\Delta l} = \mu_0 \frac{I_1 I_2}{2\pi a}$$ ↑↑ attractive

Check ↑↓ Repulsive

2. Current loop in a constant $\vec{B}$. HW ch21 h1 016-012



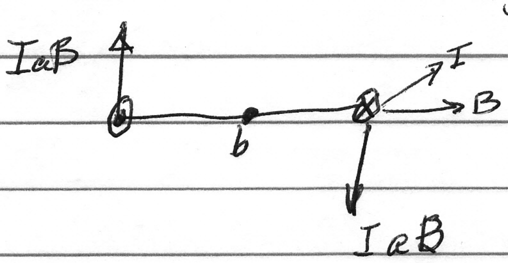
$F_1 = IaB$ ⊗

$F_2 = F_4 = 0$

$F_3 = IaB$ ⊙

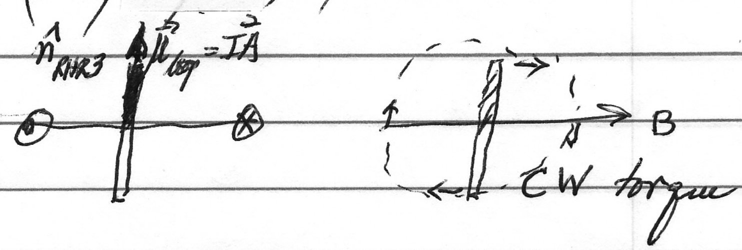
$$F^{B}_{\square} = F_1 + F_3 = IaB - IaB = 0$$

Torque about midline OO': View from the baseline loop up



$$\tau = Fb = (IaB)\,b = Ia\overset{A}{\widehat{b}}B, \quad \mu = IA = Iab.$$

Intuitive picture:



General case. h1-03-014

$$\vec{\tau} = \vec{\mu} \times \vec{B} \quad \text{Circular loop}$$

Geometry: See Figure. $\vec{B}$ is in xy plane, $\alpha < 90^\circ$

So $\vec{B} = B(-\sin\alpha\,\hat{i} + \cos\alpha\,\hat{j})$

$$\vec{\mu} = \mu\hat{j}$$

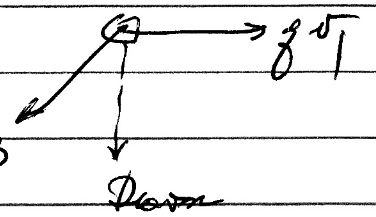
$$\vec{\tau} = \vec{\mu}\times\vec{B} = \mu B \begin{vmatrix} i & j & k \\ 0 & 1 & 0 \\ -\sin\alpha & \cos\alpha & 0 \end{vmatrix}$$

3. Circular motion: Force due to B on qv

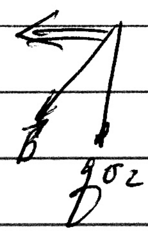
Clicker 26-4 – Given: B = const, out of the paper

Find direction of the force at P_1 & at P_2

Let me do one: at P_1



at P_2:



∴ Circular path.

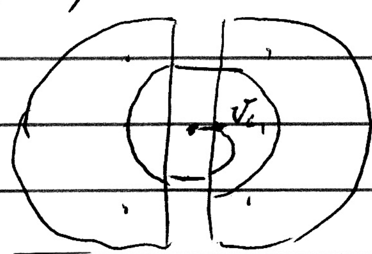
$F_{cp} = \frac{mv^2}{r} = qvB, \quad r = \frac{mv}{qB}$

Period $T = \frac{2\pi r}{v}$

$= \frac{2\pi m}{qB}$ Period is indep. of v, r.

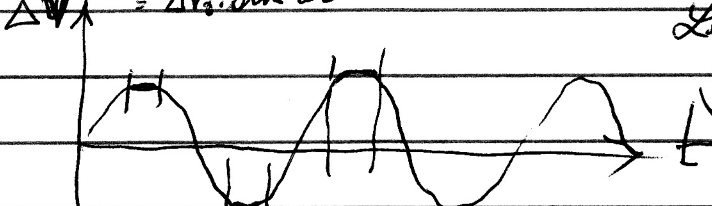
$\left(\omega = \frac{2\pi}{T} = \frac{qB}{m}\right)$

Cyclotron



Alternative $\Delta V \Rightarrow E > 0,\ E < 0$

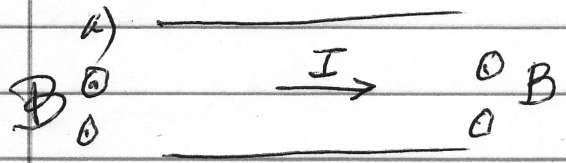
$\Delta V = \Delta V_0 \sin \omega t$



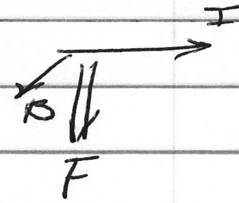
Lead acceleration of charged particle

4. Hall effect: Determine the sign of charge carriers.

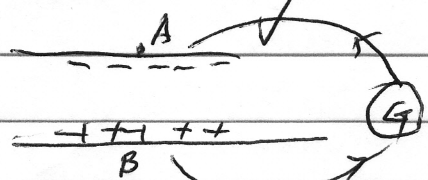
a)



$\vec{F} = \vec{I} \times \vec{B}$

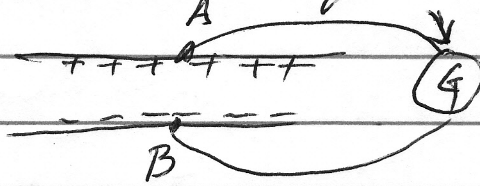


If carriers have + charges



$I_{hall} \uparrow$

If carriers have − charges



$I_{hall} \downarrow$

b) V_{hall}: After equilibrium:

For case 1: Static polarized charge create $E \uparrow$

∴ Potential at B is higher. Take a test charge to be pushed by $F = qvB$ to raise its potential from A to B

$$V_B - V_A = \frac{W_{A\to B}}{q} = \frac{q v B l}{q} = vBl$$

Case B: $E \downarrow$ $\quad V_A - V_B = vBl.$

Determination of v: $I = |q|\, i = |q| n A v$, $v = \dfrac{I}{|q| n A}$

Exercise: 2 valence electrons

$$n = \frac{\text{\# of free electrons}}{\text{vol}} \xrightarrow{\text{2 valence}} \frac{2N_A\,(\text{\# of moles})}{\text{vol}} \quad (1)$$

$$\rho = \frac{\text{molar mass } M\,(\text{\# moles})}{\text{vol}} \quad (2)$$

$$(1)/(2) = \frac{n}{\rho} = \frac{2N_A}{M}, \quad n = \frac{2N_A \rho}{M}$$