PHYS 1220, Engineering Physics, Chapter 27 – Magnetic Field and Magnetic Forces

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Goal of this chapter is to learn the magnetic force felt by the moving charged particles

- Just like charges have positive and negative; there are north and south poles in magnetism.

- Electric field lines starts at positive and ends at negative charges.
- Magnetic field lines starts at north and ends at south poles.
- In electric force, same signs of charges repel, opposite signs of charges attract.
- In magnetic force, same signs of poles repel, opposite signs of poles attract.

- Stationary charge could produce electric field, $\vec{E}=k\frac{q}{r^2}\hat{r}$; while the electric field could exert electric force on charged particle, $\vec{F}_e=q\vec{E}$.
- Gauss's law for magnetic field.

- Recall that the Gauss's law for electric field: $\Phi_E=\oint\vec{E}\cdot d\vec{A}=\frac{Q_{encl}}{\epsilon_0}$
- Similarly, Gauss's law for magnetic field: $\Phi_B=\oint\vec{B}\cdot d\vec{A}=0$
- There is no magnetic mono-pole. This is the reason why it is 0, since every north pole is accompanied by a south pole.
- The unit of magnetic field is: tesla ($1T=1N/A\cdot m$)
- The unit of magnetic flux: weber ($1Wb=1T\cdot m^2=1N\cdot m/A$)

- Moving charge could produce magnetic field (will discuss in Chapter 28); while magnetic field could exert magnetic force on moving charge, $\vec{F}_m=q\vec{v}\times\vec{B}$.
- Lorentz Force: $\vec{F}_m=q(\vec{E}+\vec{v}\times\vec{B})$

You Do Example 27.1 on page 888.

- Since there are moving electrons in a conducting wire with current, the wire will feel a magnetic force when it is placed in magnetic field.

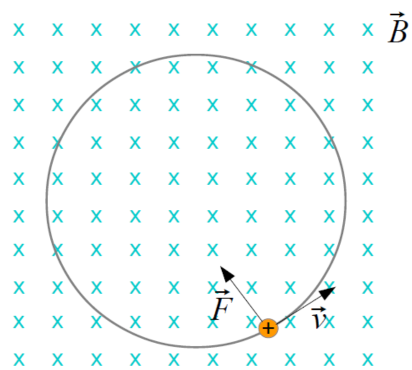
- $\vec{F}=I\vec{l}\times\vec{B}$
- If the wire is not a straight line, each section of the wire will have a small portion of the magnetic force: $d\vec{F}=I\,d\vec{l}\times\vec{B}$

- For a loop carrying a current placed in a magnetic field, the magnetic force will produce a torque which could be expressed as: $\vec{\tau}=I\,\vec{A}\times\vec{B}$ or the magnitude: $\tau=I\,A\,B\sin\phi$

- We could define a magnetic dipole moment as: $\vec{\mu}=I\,\vec{A}$
- The torque of the magnetic dipole moment in magnetic field is: $\vec{\tau}=\vec{\mu}\times\vec{B}$
- The potential energy of the magnetic dipole moment in magnetic field is: $U_m=-\vec{\mu}\cdot\vec{B}$
- If the current loop has N loops, the total torque is N times of that of one loop: $\vec{\tau}=N\,I\,\vec{A}\times\vec{B}$

- Motions of charged particle in magnetic field and its applications

- $\vec{F}_m=q\vec{v}\times\vec{B}=m\vec{a}$
- $q\,v\,B=m\dfrac{v^2}{R}=m\,R\,\omega^2$
- $R=\dfrac{mv}{|q|B}$; $\omega=\dfrac{|q|B}{m}$



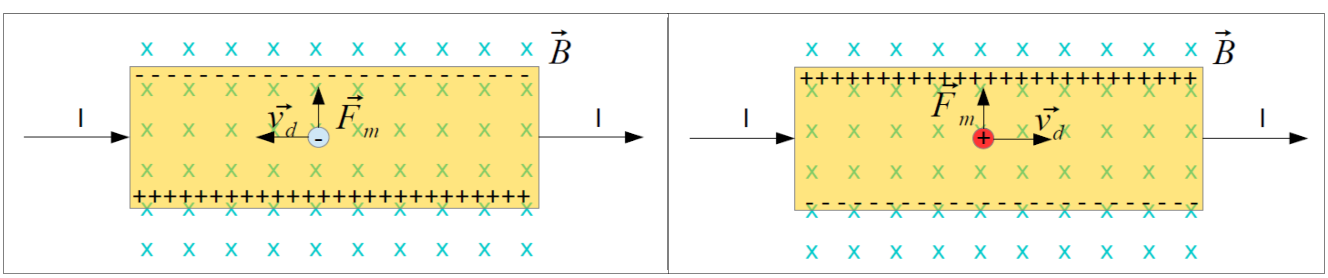
You Do Example 27.3 on page 895.

- This could be used to

1. Velocity Selector (of charged particles)
2. e/m Measurements
3. Mass Spectrometers
4. etc...

- Hall effect

- Looking into the conducting wire with current placed in magnetic field, the moving charges will feel a magnetic force that pushes them to the side wall of the wire, and generate electric field, hence electric potential laterally.



Math Preview for Chapter 28:

- Vector cross product
- Vector integration

Questions to think about for Chapter 28:

- Will two parallel wires carrying same direction current exert magnetic force on each other (either attract or repel)?